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Energy Metabolism in Relation to mating in the Male Accessory Reproductive Gland and Fat Body in *Odontopus varicornis* (Heteroptera: Pyrrhocoridae)

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Abstract: The significant reduction of pyruvate, after mating, in the accessory reproductive gland of the promiscuous bug, *O. varicornis*, remaining in copula almost all through its life indicates the oxidation of pyruvate for energy contribution to the sperms. To augment the energy needs, the gland converts lactate to pyruvate, reflected by reduction of lactate level and concomitant increase of LDH activity after mating. On the other hand the lactate level in the fat body and haemolymph has increased due to mobilization of glycogen or glucose in the fat body and the pyruvate not utilized is converted to lactate due to oxygen debt. The occurrence of rich concentration of pyruvate and glutamate and the fact that glutamate can react with pyruvate to form α-ketoglutarate suggests that α-ketoglutarate establishes this fact. The enhanced SDH and MDH activities, after mating, in the gland and fat body, reflect the enhanced metabolic activities of these tissues engaged in replenishment.

Keywords: Energy metabolism, mating, Accessory reproductive gland, fat body, α-ketoglutarate.

INTRODUCTION

The secretion of the male accessory reproductive gland has been implicated in the formation of spermatophore, production of seminal fluid, capacitation and nourishment of sperms stimulation of oogenesis and oviposition, influence on sexual behaviour and conversion of JH-I acid to storable JH-I (Leopold, 1976; Shirk *et al.* 1983; Chen, 1984; Glitho and Huignard, 1990; and Couche and Gillott, 1990). In mosquitoes these glands have been shown to synthesize JH I and III de novo. (Dov Borosky *et al.* 1994).

Fat body, the principal tissue for intermediary metabolism in insects is the main source for the haemolymph proteins, lipid and carbohydrates that serve as precursors for metabolism in other tissues (Keeley, 1985). Oxidative metabolism occurs in the fat body of insects via the TCA cycle and electron transport, just as it does in other animals. Fat body has been shown to contribute some proteins through the haemolymph for the accessory glands (Friedel and Gillott, 1976; Ranganathan, 1982; Basker and Ranganathan, 1987).

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Energy metabolism in insects other than flight has not been studied well (review: Sacktor, 1975). Glycolysis in insects is known to yield pyruvate and glyco-phosphate (Sacktor, 1970). Pyruvate apart from being formed by glucose metabolism is also formed from the carbon skeletons of a number of amino acids such as serine, alanine and cysteine. Pyruvate occupies a central place in metabolism since it participates in many other reactions (Smith *et al.* 1985). α-ketoglutarate has been shown as a preferred energy substrate for the spermatozoa and as an accelerator for sperm respiration in *Bombyx mori* (Osanai *et al.* 1987).

Earlier biochemical studies on the accessory reproductive gland in *Plebeiogryllus guttiventris, Chrysocoris purpureus, Aspongopus janus* and *Odontopus varicornis* (Ranganathan, 1970a,b, 1973, 1980; Ranganathan *et al.* 1984; Ranganathan and Padmanabhan, 1994) have shown that energy to the sperms, during their transfer to the female, is supplied from the secretions of the gland.

Since energy metabolism of reproduction in male insects has not been studied, investigations were made on the TCA enzymes, succinate dehydrogenase and malate dehydrogenase and GDH and LDH and the levels of pyruvate and lactate in the accessory reproductive gland of *Odontopus varicornis* before and after mating. A unique feature of *Odontopus varicornis* is that, adults remains in copula almost all through its adult life except at times of oviposition and senescence. Study of oxidative enzymes would show whether pyruvate was being utilized to supply energy. As pyruvate and lactate are related, estimations of lactate and LDH were made. The studies were extended to fat body- the storage organ, to know how far this organ contributes to sustain the supply of metabolites via the haemolymph-being the medium for translocation of the same.

MATERIALS AND METHODS

Odontopus varicornis was collected from the agricultural farm of the University and reared under laboratory condition of 28 ± 1°C. 70% RH and fed with germinated cotton seeds. Ten days old adult males were used for all the biochemical estimations. 15 animals were sacrificed for each estimation.

Estimation of Lactic Acid

Lactic acid in the tissue was estimated by the method of Barker and Summerson (1941).

Pyruvic acid in the tissues was estimated adopting the method of Friedman and Haugen (1943).

The enzyme SDH is assayed by Bernath and Singer (1962) method.

GDH activity was assayed by the method of Strecker (1965).

LDH is assayed by the method of King (1965).

RESULTS

Pyruvic acid

Pyruvate activity is very high, both before and after mating, in the gland, fat body and haemolymph than the lactate activities in these tissues. The peak activity of the

pyruvate found in the accessory gland, before mating, become reduced by 17.8% after mating. More or less the same trend is observed in the fat body but the noticeable feature is that the pyruvate level of the fat body is just half of that of the accessory gland and becomes reduced by 13.67% after mating. Pyruvic acid in the haemolymph, before mating, is not only the lowest of the tissues but also it becomes increased by 154% after mating (vide: Table 1 and Fig. 1).

Compared to the level of pyruvic acid the lactic acid content is meagre. Though the accessory gland, before mating shows the highest level of lactic acid, it is more than ten times lesser than pyruvic acid level of the gland of the same stage.

Table 1: Pyruvate, lactate, SDH, GDH and LDH activities in the accessory reproductive gland, fat body and haemolymph of male *Odontopus varicornis* before and after mating (Pyruvate and lactate values are expressed in μ moles/g; enzymes μ moles /mg)

Tissue	Stage	Before mating	After mating	
MARG	Pyruvate	90.11 ±2.61	74.09 ±4.09	P<0.002
	Lactate	8.60 ±3.90	2.60 ±0.40	P<0.001
	SDH	0.016±0.0030	0.035±0.004	P<0.001
	MDH	0.002±0.0002	0.005±0.004	P<0.001
	GDH	0.002±0.0009	0.003±0.0006	P<0.002
	LDH	0.001±0.0002	0.006±0.006	P<0.001
MARG	Pyruvate	44.43 ±3.07	38.40 ±3.29	P<0.001
	Lactate	1.70 ±0.24	5.30 ±0.44	P<0.002
	SDH	0.0022±0.00054	0.0037±0.00054	P<0.001
	MDH	0.0007±0.00013	0.0018±0.00041	P<0.001
	GDH	0.0002±0.00007	0.0007±0.00018	P<0.001
	LDH	0.0004±0.00010	0.0009±0.00003	P<0.001
Haemolymph	Pyruvate	11.81 ±1.47	29.54 ±2.25	P<0.001
	Lactate	0.86 ±0.10	1.33 ±0.23	P<0.001

The lactic acid in the gland becomes reduced by 75% after mating. But the lactic acid content in the fat body and haemolymph has increased, after mating, by three, and one and half a times respectively (vide Table 1, Fig. 2).

Enzymes

In general, after mating, there is an increase in the activity of all the four enzymes in all tissues (vide Table 1 and Fig. 2). The increase in the enzyme content, after mating, is more than two fold for SDH and MDH and one and a half fold for GDH in the gland but six times for LDH in the gland and more than two times in fat body. Of the two tissues, the gland exhibits the highest activity in all the enzymes, followed by the fat body. A unique feature observed is that, of the four enzymes, the SDH activity is the highest in the tissues, the top position occupied by the gland, especially after mating (0.035μmoles DCIP reduced/mg protein/min) (Fig. 2). Following the SDH activity the MDH activity is more, particularly in the gland. GDH activity is also more in the gland than fat body and increases in activity in both the tissues after

Fig. 1. Pyruvate and lactate activities in the accessory reproductive gland, fat body and haemolymph of male *Odontopus varicornis*

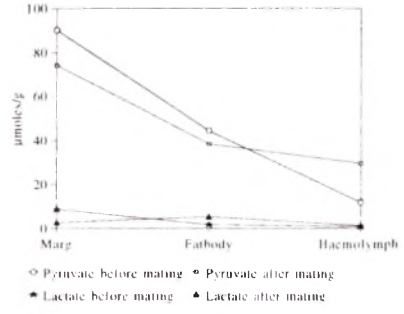
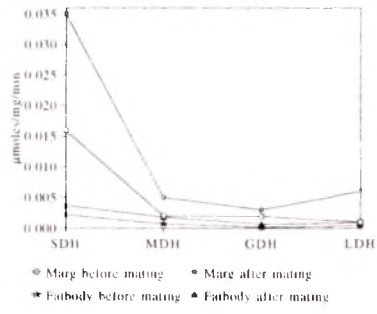


Fig. 2. SDH, MDH, GDH and LDH activities in the accessory reproductive gland, fat body and haemolymph of male *Odontopus varicornis*



mating. LDH activity is very poor, after mating, in the tissues except for the gland and follows the same pattern of activities of SDH, MDH and GDH.

DISCUSSION

Energy metabolism related to reproduction in insects is little understood. Carbohydrates, chiefly glucose and glycogen in the accessory reproductive gland have been shown to be utilized in the elaboration of seminal plasm and provide energy for sperms through glycolysis in *Plebeiogryllus guttiventris, Chrysocoris purpureus* and *Aspongopus janus* (Ranganathan, 1970a, 1973; Ranganathan *et al.* 1984). The energy needs of *O. varicornis* ought to be greater in view of the peculiar, prolonged mating behaviour. Recent studies on this insect have shown triaclyglycerol from the gland to contribute to the energy needs for mating (Ranganathan and Padmanabhan 1994).

Pyruvate is the metabolite which is oxidised to CO_2 and water in the TCA cycle in mitochondria yielding energy as ATP and in this process α-ketoglutarate is one of the intermediates. Pyruvate has been known to provide energy for the cells in the very early delicate stages of development when they are unable to utilize glucose (Marx, 1973). α-ketoglutarate has been demonstrated as a preferred energy substrate for the spermatozoa and an accelerator for the sperm's respiration in *Bombyx mori* (Osanai *et al.* 1987). The rich presence and significant reduction of pyruvate in the gland, after mating, in *O. varicornis* indicates the oxidation of pyruvate for energy contribution.

One of the functions of the secretions of the MARG is sperm activation, capacitation and nourishment (Ranganathan, 1982; review; Couche and Gillott, 1990). These conclusions were from histochemical and biochemical evidences but the present enzymological study has provided support for the above roles of the secretion by the demonstration of the TCA cycle. After mating, an increase of oxidative enzymes viz., SDH and MDH and a reduction of pyruvate in the gland of *O. varicornis* are strongly suggestive of the operation of TCA cycle. Though it was not possible to estimate the TCA cycle metabolites in view of their highly labile and dynamic nature,

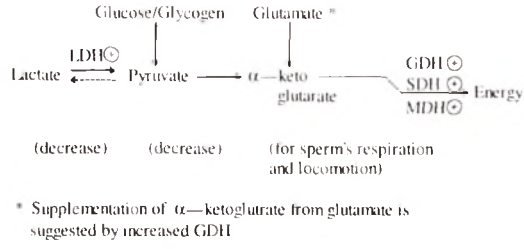


Fig. 3 Metabolic route in the accessory reproductive gland of *O. varicornis*

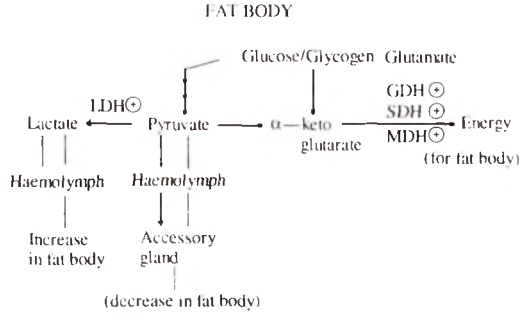


Fig. 4 Metabolic route in the fat body of *O. varicornis*

an increase of GDH suggests that the amino acid, glutamate, may also be utilized and converted to α-ketoglutarate-a preferred energy substrate of sperms, to augment the energy resources in *Odontopus* since this bug is continuously mating where the energy demand for mating could not be adequately met by the TCA cycle. Further earlier observations of the amino acid composition of the accessory gland of *Plebeiogryllus guttiventris* and *Chrysocoris purpureus* (Ranganathan, 1970b, 1980) have revealed the presence of rich concentration of glutamate. Also GDH has been shown to be an enzyme active in the nitrogen and energy metabolism in insects (Teller, 1988).

Under condition of energy demand, pyruvate will not be converted to lactate or will diffuse into the lymph from the gland. Of all the enzymes investigated in the present study LDH activity is the lowest and this is in conformity with a similar finding of Chefurka (1965) in the accessory gland and fat body of *Periplaneta americana*. More over, if pyruvate is converted to lactate, the concentration of lactate should increase, whereas in the present study on *Odontopus*, it has actually decreased in the gland. Hence, the suggested mechanism is as shown in Fig. 3.

Earlier, the promiscuity of *Melanoplus sanguinipes* had been shown to require very active accessory glands in males, supplemented with fat body in the replenishment of the secretion (Friedel and Gillott, 1976). Investigations on fat body were done to find out how far this organ could lend metabolic assistance to accessory gland of

Odontopus varicornis which remains in copula almost throughout its adulthood.

Exactly as in the case of accessory gland, there is an increase of oxidative enzymes SDH and MDH with a decrease of pyruvate, though the extent of decrease is not as much as in the gland. In addition to oxidation of pyruvate, it is possible that some amount of pyruvate could diffuse out to the haemolymph for onward migration into the accessory gland for utilization. Thus, a decrease of pyruvate after mating is expected.

It is known that during physical activities there could be oxygen debt and accumulation of lactate in the muscle but not in other organs. Unlike in the accessory gland, there is an increase of lactic acid. It is likely that glucose or glycogen gets metabolized in fat body and the pyruvate not utilized is perhaps converted to lactate due to temporary oxygen debt, to be utilized in times of need (Fig. 4). Further the enhanced LDH in the fat body, after mating, with concomitant reduction of pyruvate indicates the conversion of pyruvate to lactate.

Increase of GDH in fat body is suggestive of augmented production of α-ketoglutarate from glutamate.

An increase in pyruvate and lactate in haemolymph after mating could be due to seepage of the same from fat body in the process of replacement of pyruvate for the accessory gland.

It appears that there is the operation of TCA cycle in MARG of *Odontopus varicornis* and utilization of pyruvate and α-ketoglutarate to cater to the excessive needs of energy as the insect remains in copula almost throughout its adulthood. There is also a biochemical picture in the fat body which appears to contribute metabolites to sustain the supply of energy via the medium of haemolymph.

Acknowledgement

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Effect of Thermal Neutron Flux Radiation on Cephalic Neuroendocrine System of the Fruit-Sucking Moth, *Othreis materna* (Linn.) (Lepidoptera: Noctuidae)

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Abstract: The medial A1 neurosecretory cells and the epithelial cells of the CA in the adult female of *Othreis materna* undergo cyclic changes soon after emergence. The secretory activity of the medial A1 cells and the corpora allata in the female developed from the irradiated pupa is greatly reduced, retarded and does not coincide with that of the control ones. The ultrastructural studies on the medial A1 cells of the irradiated pupa reveal formation of large vacuoles and lysosomal bodies, severe damage of the subcellular organelles and marked degranulation of the neurosecretory granules which seem to be the root-cause of retarded neuroendocrine activity in the adult moth emerged from the irradiated pupa.

Keywords: Neutron flux irradiation, cephalic neuroendocrine system, corpora allata, *Othreis materna*.

INTRODUCTION

With an introduction of sterilization techniques in integrated pest management, radiation-induced changes in the neuroendocrine system have been elucidated particularly, in relation to vitellogenesis and sterility in some insects (Adams *et al.* 1972; Harshberger, 1974, Unnithan and Nair, 1977, Khurad, 1979; Jankovick-Hladni *et al.* 1983; D'Amelio *et al.* 1984; Johnson and Vail, 1987). From these studies it becomes obvious that the radiation causes severe damage to the subcellular structure of the medial neurosecretory cells and the corpora allata and reduces their activity to such a great extent that the vitellogenesis is adversely affected. The detail information is, however, obscure.

The female, fruit-sucking moth, *Othreis materna* emerged from the irradiated pupa lays the sterile eggs and this method can be applied in the integrated pestmanagement designed for this pest (Mohite, 1989). Subsequently, the present work was undertaken to investigate the radiation induced changes in the medial A1 neurosecretory cells of the brain and the corpora allata involved in the regulation of vitellogenesis in the fruit-sucking moth, *Othreis materna*.

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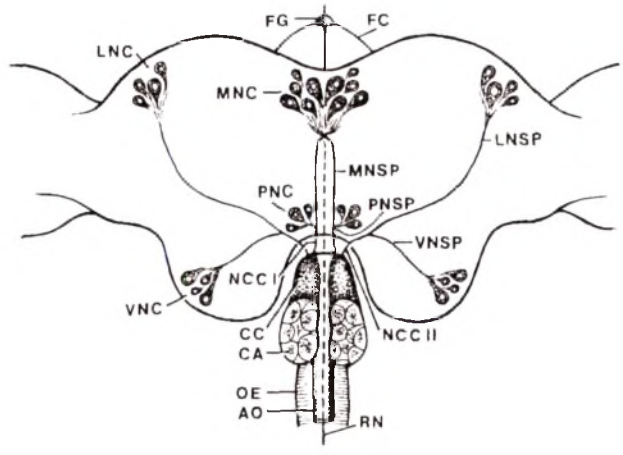


Fig. 1. The cephalic neuroendocrine system of an adult *Othreis materna* (Diagrammatic).
Abbreviations: AO–aorta, CA–corpus allatum, CC–corpus cardiacum, FC–frontal connective, FG–frontal ganglion, LNC–lateral neurosecretory cells, LNSP–lateral neurosecretory pathways, MNC–medial neurosecretory cells, MNSP–medial neurosecretory pathways, NCCI–nervi corporis cardiaci interni, NCCII–nervi corporis cardiaci externi, OE–oesophagus, PNC–posterior neurosecretory cells, PNSP–posterior neurosecretory pathways, RN–recurrent nerve, VNC–ventral neurosecretory cells, VNSP–ventral neurosecretory pathways.

MATERIALS AND METHODS

Collection and rearing method

The adult moths were collected from the orange orchards during nights and were brought to the laboratory for rearing. Development from an egg to adult, took a period of 32-36 days at the room temperature (22-24°C) and humidity (60-65%). All larval instars were fed on the green leaves of the climber *T.cardifolia* and the adults on ripe orange fruits. The 7-day old females often start laying eggs in the laboratory. The rearing method was described in detail elsewhere (Shinde, 1990).

Exposure to Neutron flux Radiation

Three-day old pupae about 100 in number were taken out from the culture and divided into two equal groups. The pupae of the group were exposed for one hour to whole body radiation of neutron flux at the rate of 1.5×15^5 neutrons/sec/cm^2 from a source of American Beryllium with the help of Neutron Howitzer Ty. NH 11(15) (Electron Company of India Limited). The untreated pupae of another group served as controls.

Light microscopic method

The adult females developed from pupae of both the groups were separated from the males on the basis of difference in wing colouration. The cephalic neuroendocrine system was dissected out on every day since emergence till the control moths undergo oviposition, *i.e.*, seventh day.

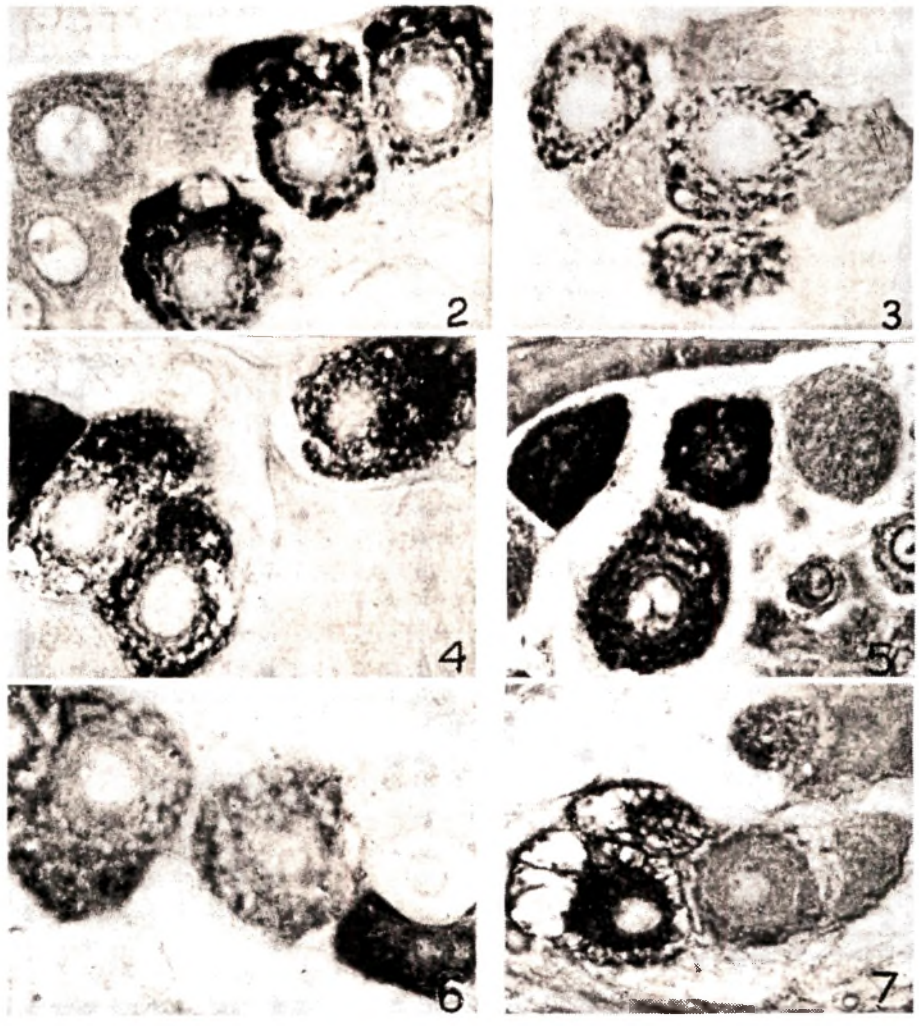


Fig. 2-7. Sections passing through the medial A1 cells in the pars intercerebralis region of the brain of females developed from control-(figs. 2, 4, 6) and irradiated pupae (Figs. 3, 5, 7) CHP (× 640).

The cephalic neuroendocrine organs were fixed in aqueous Bouin's fluid for 18-24 hours, washed, dehydrated, cleared in xylene and embedded in paraffin wax (60°C). Sections were cut at 4 μm thickness and stained with either Bergman's chromalum haematoxylin-phloxin (CHP) or Ewen's Aldehyde fuchsin (AF) staining techniques (Panov, 1980).

Electron microscopic method

The cephalic neuroendocrine system of three-day old irradiated and control pupae was gently dissected out and fixed in 3.5% glutaraldehyde dissolved in 0.1M phosphate

Table 1: Cytomorphological characteristics and Distribution of the Neurosecretory Cells in Brain of an Adult *Othreis materna*

Cell type	NSM Staining		Size (μm)		NSG size (A)	Distribution
	CHP	AF	Cell	Nuclei		
A1	Blueblack	Purple	34.40±0.52	14.50±0.42	8400	MNC
A2	Blueblack	Purple	25.30±0.33	13.00±0.48	7500	MNC, LNC
B	Red	Greenish	20.61±0.28	11.92±0.18	5300	MNC, PNC, LNC, VNC
C	Light blue	Brown	31.62±0.74	15.63±0.31	6400	MNC, PNC, LNC, VNC

buffer (pH 7.2) for 6 hours. The material was thoroughly washed and post-fixed in 1% osmium tetraoxide dissolved in the similar concentration of phosphate buffer for 1 hour. The material was stained *en block* with 0.5% uranyl acetate during dehydration with graded alcohols and embedded in araldite or styrenemetacrylate.

The ultrathin sections were collected on pioloform coated grids after cutting with glass knife on the LKB 2005-5 Ultratome and observed under the Phillips 200 EM at desirable magnifications. In order to identify cerebral medial A1 cells, 0.5 μm thick alternative sections were cut at the beginning and were stained with AF according to a method of Steel and Morris (1977) and Tembhare (1980).

RESULTS

The Cephalic Neuroendocrine System

In the pupae and adults of *O.materna* the cephalic neuroendocrine system commonly consists of the neurosecretory cells in the brain, a pair of corpora cardiaca (CC) and a pair of corpora allata (CA) Fig. 1. The prothoracic glands were found in the pupa but they undergo complete degeneration in the adult stage. The histology and ultrastructure of the system has been described in detail elsewhere (Shinde, 1990).

There are four groups of neurosecretory cells (NSC) in each hemisphere of the brain. The medial, lateral and posterior groups are situated in the mid-dorsal, anterolateral and postero-ventral regions of the protocerebrum, respectively. The groups of ventral neurosecretory cells are located in the tritocerebral lobes. On the basis of staining and cytomorphological characteristics, the medial, lateral and posterior as well as ventral neurosecretory cells are classified into the A1, A2, B, C; A2, B, C and B, C cells types, respectively (Table 1). The axons of medial and posterior NSC constitute a pair of nervi corporis cardiaci interni (NCC-I) and those of lateral and ventral NSC form another pair of nerves, the nervi corporis cardiaci externi (NCC-II). The NCC-I and II emerged out of each hemisphere of the brain enter the corpus cardiacum of their own side. The CC are paired, fusiform bodies and are internally consisting of the cerebral neurosecretory axons, intrinsic neurosecretory cells and few glial cells. The nervi corporis allati-I and II are indistinct as the CC are connected to the CA closely. The CA are spherical or oval structures consisting of a connective tissue sheath externally and the spherical epithelial cells with large nuclei internally.

In the pupa, as well as adult moths, the NSC, NCC-I and CC contain a variable quantity of the neurosecretory material and NSC often show cyclical secretory activity.

The medial A1 cells and CA show profound secretory activity in the female since emergence till oviposition and play an important role in vitellogenesis by acting as the source of allatotrophic and gonadotrophic hormones, respectively (Shinde, 1990).

Effect of Neutron flux Radiation

Light microscopic studies

The medial A1 cells resume secretory activity in 1-day old control females. The A1 cells, along with their axons, contain a large quantity of neurosecretory material (NSM) showing enhanced synthesis and transport of NSM in 2-day (Fig. 2) and 4-day (Fig. 4) old females, while they are almost devoid of NSM in 6-day old females (Fig. 6).

In the females that developed from the irradiated pupae, moreover, the medial A1 cells resume secretory activity on the second day (Fig. 3) and the A1 cells and their axons are loaded with NSM in 4-day old females (Fig. 5), while they are greatly vacuolated in 6-day old females (Fig. 7).

The CC contain variable amount of NSM in the females of control group (figs. 8, 10, 12), but are devoid of NSM in the 2-day and 6-day old experimental females, although it was initially appeared in 4-day old ones (Figs. 9, 11, 13).

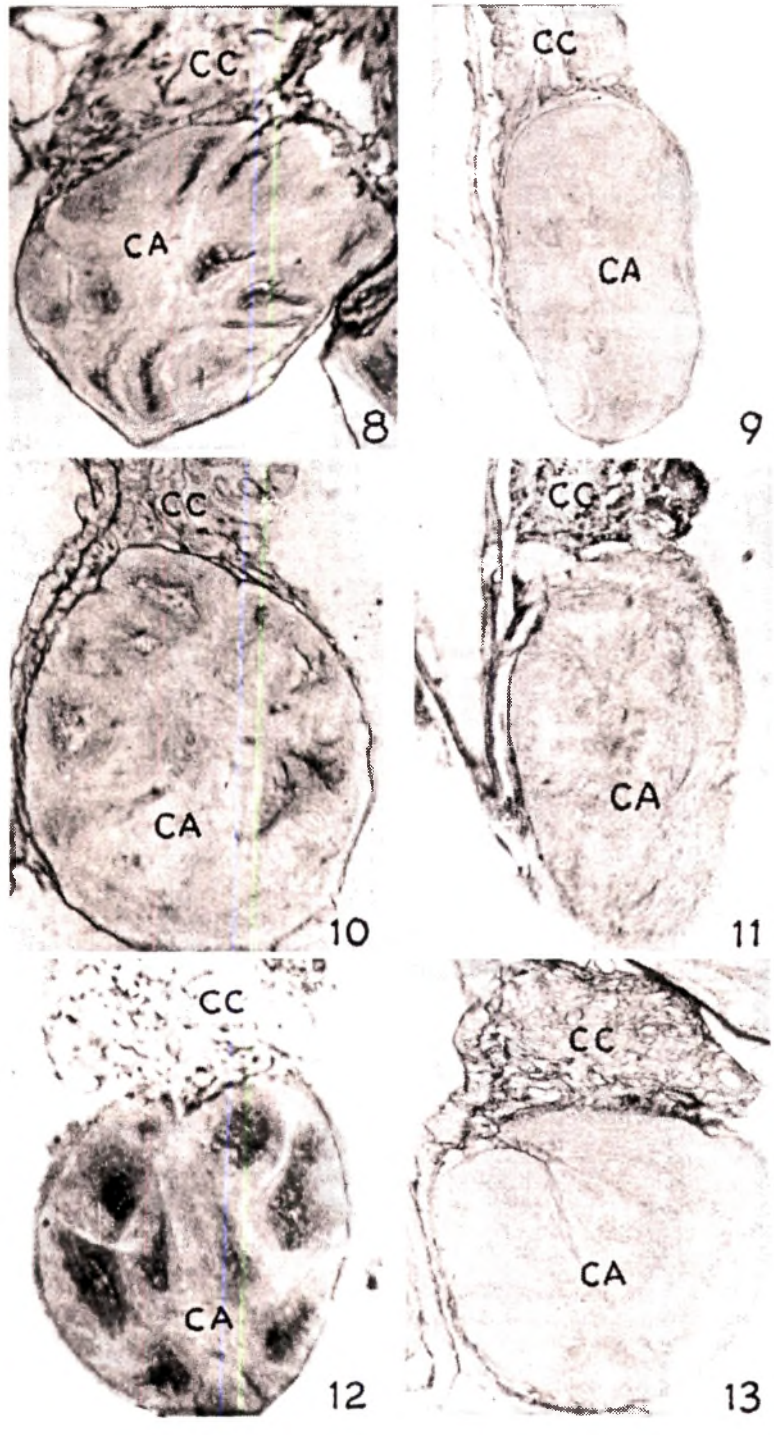
The CA of the females developed from the control pupae are often larger than those developed from the irradiated ones (Table 2). The nuclei of the epithelial cells of CA are comparatively large and contain intensely stained chromatin mass in the females of control group (Figs. 8, 10, 12). While those of the females emerged from the irradiated pupae are indistinct and their chromatin mass is absolutely unstained (Figs. 9, 11, 13).

EM Studies

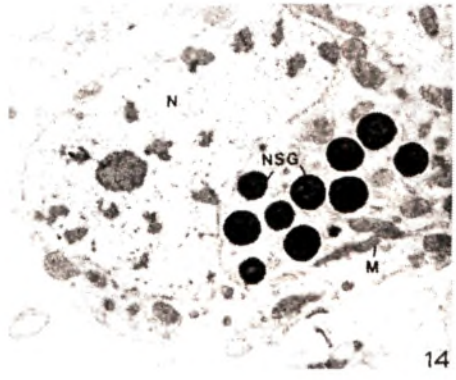
The EM studies on the cerebral medial A1 cells show intact cytoplasmic organelles and a group of dense neurosecretory granules (NSG) in the perikarya (Fig. 14) in control pupae, but destruction of mitochondria and other cytoplasmic organelles, p-resence of lysosomal and large vacuole bodies and lysis of NSG (Fig. 15) in the irradiated pupae.

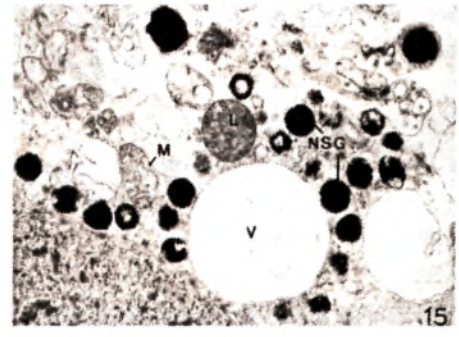
DISCUSSION

The present study revealed a delay of one day in the onset of neurosecretory activity in the A1 cells in the females developed from irradiated pupae. Similarly an accumulation and transport of little quantity of NSM in only the 4 day old females and vacuolization and resorption of NSM in 6 day old moths developed from the irradiated pupae suggest greatly retarded and deficient secretory activity in the cerebral medial A1 cells and therefore support the findings of earlier workers (Khurad, 1979 D,Amelio *et al.* 1982, 1984; Jankovic-Hiladni *et al.* 1983; Johnson and Vail, 1987). Adams *et al.* (1972) and Khurad (1979), however, noticed a reduction in the volume of CA and cessation of the activity in females emerged from irradiated pupae and it was also well-evident in *Othreis materna*.



Figs. 8-13. Sections passing through the CC-CA complex of females developed from control- (Figs. 8, 10, 12) and irradiated pupae (Figs. 9, 11, 13). CHP (× 200). (For abbreviations–see Fig. 1).





Figs. 14-15. EM sections of the medial A1 cells in the pars intercerebralis region of the brain of control (Fig. 14) and irradiated pupae (Fig. 15) (×10000).
L–lysosome, M–mitochondria, N–nucleus, NSG–neurosecretory granules, V–vacuole

Table 2: Effect of thermal neutron flux radiation on the volume of corpora allata of the adult females of *Othreis materna*

Age of female moth (days)	CA Volume (μ m^3)	
	Control	Experimental
0 (Newly emerged)	21947.294±24	21819.242±28 NS
1	25567.053±47	25418.255±40 NS
2	28256.025±65	26829.142±52*
3	31802.784±85	28527.582±62*
4	33480.572±57	30638.294±48*
5	36402.955±26	30528.572±35**
6	40191.174±18	34529.570±32**
7	39632.461±44	52622.592±63*

*P <0.1, **P <0.001

Harshberger (1974) reported that the irradiation caused the destruction of chromosomes, cytoplasmic organelles and enzymes, while Unnithan and Nair (1977) noticed severe damage to the subcellular organelles in the medial neurosecretory cells. The present study revealed not only the destruction of the cytoplasmic organelles but also the formation of vacuoles, lysosomes and lysis of NSG in the perikarya of medial A1 cells in the irradiated pupae which seems to be the major root-cause of a greatly retarded secretory activity of the medial A1 cells and CA in the adult female moths emerged from the treated pupae.

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Effect of time of planting and harvesting of Sweet potato (*Ipomoea batatas* (L.) Lam.) on yield and insect damage in South-Eastern Nigeria

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Abstract: Sweet potato (*Ipomoea batatas* (L.) Lam.) CV. TIS 87/0087 was planted in a randomised complete block design in 1992 and 1993. This was done at fortnightly intervals. Five planting and four harvestings were carried out during each year. Harvesting was done at 28 days intervals starting from 12 weeks after planting. Results showed that the yield of foliage, root tubers and the damage by *Cylas puncticollis* and *Acraea acerata* were affected mainly by the amount and distribution of rainfall. Highest yields were obtained when sweet potato was planted at the month when the rainfall was between 200 to 250 mm. Delayed planting resulted in reduced yield because of increasing amount of rainfall. Although the yields of tubers increased with delayed harvesting, increase in *C. puncticollis* and *A.acerata* damage as a result of reduced rainfall do not make harvesting beyond 20 w.a.p profitable.

Keywords: *Ipomoea batatas Cylas puncticollis, Acraea acerata,* planting and harvesting dates

INTRODUCTION

Sweet potato *Ipomoea batatas* (L.) Lam.) is one of the important root crops of the sub-Saharan African Countries (Okigbo, 1986). It is grown under a wide range of environments as annual crop, but it is most adapted to areas with high and well distributed rainfall during the growing season (Gollifer, 1980). It has tremendous potential as an efficient and economic source of food energy. Both the tubers and the leaves are good sources of vitamins (Alvarez, 1986). One of the major constrants responsible for low production is the lack of the knowledge of suitable times of planting and harvesting by farmers in the South Eastern States of Nigeria who in recent years have developed great interest in sweet potato cultivation. Also, because of the introduction of new cultivars it is necessary that the production technologies should be reviewed from time to time. There were also fluctuations observed in the yield of sweet potato cultivars grown at the National Root Crops Research Institute (NRCRI), Umudike and the resistance rating of the cultivars to pests in recent years. *Cylas puncticollis* Boh and *Acraea acerata* Hew. are the most common insect pests of sweet potato which reduce foliage and root yields in Africa (Robert, 1985).

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It is therefore necessary to investigate the times of planting and harvesting to address the problems. The results are discussed and are useful for the farmers to enhance their productivity and economic well being.

MATERIALS AND METHODS

The study was carried out in 1992 and 1993 using cv. TIS 87/0087. Five planting and four harvesting dates were evaluated in a randomised complete block design. The treatments were replicated thrice. The field was prepared at the same time at the beginning of the experiment. Plantings were done at fort-nightly intervals starting from 29th of May in 1992 and 23rd of June in 1993. Harvesting was done at 28 days intervals starting from 12 w.a.p. Two weedings were done and fertilizer NPK 70:15:100 ai/ha were applied at 61.a.p. by broadcasting. *Acraea acerata* damages were scrored at fort-nightly intervals. At harvest the foliage, total root tuber and saleable root tuber yields were recorded. The number of tubers infested by *C. puncticollis* and the degree of damage were also recorded. The number of tubers infested were later converted to percentages which were transformed by Arc sine transformation method. The data were analysed by the analysis of variance and the significant means were separated by the Least significant Difference (LSD).

RESULTS

The yield data for 1992 and 1993 are presented on Table 1 and 2 while the rainfall data for the two years are presented on Table 3. There was a high significant difference in the yields of foliage in 1992 due to the effect of planting dates (Table 1), while the effect of times of harvesting was significant at P=0.05 (Table 2). Both time of planting and harvesting effects on tuber yields were highly significant (P=0.01) in 1993. While there was no significant interaction in 1992, this was significant at P=0.05 in 1993. The foliage yield was highest from the first planting and decreased with delayed planting. Also the harvest made at 12 w.a.p. gave the highest foliage yield and decreased subsequently. The total and saleable root tuber yields showed high significant differences. In 1992 the highest root yield was recorded from planting done during the second part of May, while the least was from those planted during the second part of July.

In 1993 the highest yield was recorded from sweet potato planted during the first part of July while the least yield came from those planted in August. The result showed that while the yields from late June planting in 1992 were better than those in 1993, yields from early July in 1993 were better than those from the corresponding time in 1992. The results also showed that time of harvesting significantly affected both the total and saleable root tuber yields. Sweet potato harvested at 24 w.a.p gave the highest yields while those harvested at 12 w.a.p. gave the least yield. In 1993 the yield from 24 w.a.p was not significantly different from yields at 20 w.a.p. the percentage *C.puncticollis* infestation showed significant differences due to time of planting and harvesting. The percentage infestation increased with late planting and harvesting. While there was no *Cylas* infestation on tubers from the earliest planting (June) in 1993 and the first harvesting (12 w.a.p) there was however infestation in the corresponding period in 1992. There was no incidence of *A. acerata* in 1992 while

Table 1: Effect of time of planting on yield and pest damage

	Yields t/ha						% Infestation		Degree of damage (0 – 5)			
Planting	Foliage		Total Roots		Saleable tubers		*Cylas* (T)		Cylas		*A. acerata*	
Dates	1992	1993	1992	1993	1992	1993	1992	1993	1992	1993	1992	1993
*May	12.46	–	20.73	–	19.79	–	4.81	–	0.88		–	–
*June	8.91	–	19.21	–	15.78		4.40		0.25		–	–
**June	6.89	11.51	15.21	14.13	12.73	12.46	6.54	0.00	1.17	0.00	–	1.76
*July	0.03	7.60	7.10	19.34	4.35	17.26	14.35	10.93	1.54	1.36	–	2.40
**July	–	4.91	–	13.19	–	10.44	–	14.78	–	1.29	–	2.49
*Aug.	–	3.03	–	8.83	–	7.59	–	17.10	–	1.75	–	2.45
**Aug.	–	2.42	–	8.02	–	5.74	–	22.41	–	2.00	–	2.14
LSD =	2.54	2.16	4.91	2.77	4.78	3.15	7.37	9.12	0.79	0.96		0.31

* = First half of the month (1^{st} - 15^{th} day)
** = Second half of the month (16^{th} - 31^{st} day)

Table 2: Effect of time of harvesting on yield and pest damage

	Yields t/ha						% Infestation		Degree of damage (0 – 5)			
Time of	Foliage		Total Roots		Saleable tubers		*Cylas* (T)		Cylas		*A. acerata*	
harvesting	1992	1993	1992	1993	1992	1993	1992	1993	1992	1993	1992	1993
12 w.a.p.	8.89	8.35	8.49	8.84	6.76	6.96	1.75	0.00	0.13	0.00	–	1.48
16 w.a.p.	7.98	6.41	15.57	12.80	13.51	11.33	6.89	3.46	0.72	0.50		2.09
20 w.a.p.	7.34	5.23	15.73	13.62	13.66	11.04	6.77	16.36	0.80	1.70	–	2.58
24 w.a.p.	5.78	3.59	21.42	15.54	18.14	13.46	19.98	32.36	2.43	2.92	–	2.84
LSD = 0.05	2.27	1.93	4.39	2.48	4.28	2.82	6.59	8.15	0.71	0.86	–	0.28

it caused significant damage on the leaves in 1993 which increased with delayed planting and harvesting.

DISCUSSION

The results showed that good yields of sweet potato are obtained when the vines are planted within four weeks after seed bed preparation provided that the total monthly rainfall lies between 200 to 250 mm. Best yields are obtained when 62 to 95 mm of the total rainfall falls within the two weeks after planting (Table 1 and 3). From the results, the yields of tubers were highest from sweet potato planted in late May 1992 and early July 1993 which received a total rainfall of 207.4 and 253.4 mm respectively. According to Nwinyi, (1992), the sunlight hour is positively correlated with yield of sweet potato and inversely correlated to rainfall. Tables 1 and 3 showed that delayed plantings coincided with increased rainfall which affected the sunlight hours and consequently the photosynthetic activities of the plants. The highest foliage yield at 12 w.a.p showed that this is the time of maximum vegetative production. This is in

Table 3: Rainfall Data (mm)

Month	1992		1993	
	$1^{st} - 15^{th}$ day	$16^{th} - 31^{st}$ day	$1^{st} - 15^{th}$ day	$16^{th} - 31^{st}$ day
Jan.	**0.0	**4.6	**0.0	**0.0
Feb.	**0.0	**0.0	**0.0	*37.9
Mar.	*39.0	*80.0	*92.2	**2.5
April	*74.4	*71.4	*11.5	171.8
May	*47.9	159.5	*84.5	*31.0
Jun.	*62.2	167.3	200.4	228.5
July	236.9	203.2	158.3	*95.1
Aug.	159.8	170.2	*97.1	128.7
Sept.	250.5	266.6	206.1	109.5
Oct.	*83.1	119.5	100.1	102.9
Nov.	*58.4	*58.4	*11.5	*128.8
Dec.	**0.0	**0.0	*15.7	**0.0

agreement with earlier reports by Lowe and Wilson (1974); Hahn and Hozyo (1984). Because of the short growth cycle of the crop, the foliage decreased progressively with delayed harvesting. The highest root yields from crops harvested at 24 w.a.p. is attributed to longer period of sunlight hours which increased the photosynthetic activities on the leaves (Secreto and Vilamayer, 1985). This however depends on the growth cycle of the cultivar. Early maturing cultivars (3-4 month) like CV. TIS 8441, will shed their leaves after this period and any delayed harvesting will lead to reduced yields due to rodents and insect damages. The percentage of *C. puncticollis* infestation increased significantly with delayed planting and harvesting. There is higher *Cylas* build up on old planting materials that are used in late plantings than those used at the early stages of their growth from the nursery (Annon, 1978 and Talekar, 1989). Because of the higher inoculum on late planted materials there were higher damage on the crop. Delayed harvesting enters often into the dry season in Nigeria when the high temperatures and reduced rainfall favour the development of insects (Hahn and Anota, 1981). The abscence of *A.acerata* incidence in 1992 is attributed to the adverse weather conditions for the insects. The high rainfall between the months of July and September did not favour the insect development. In 1993, the earliest planted and harvested crops had the least damage by *A.acerata*. The plants were able to escape severe attack due to early harvesting before the cessation of rains.

The damage by *A.acerata* contributed to lower foliage yields. Sweet potato leaves are useful sources of vitamins for man and also are used for feed for livestock (Alvarez, 1986). The best time of planting sweet potato is therefore not specific with the month of the year in any location but must be guided by the weather situation especially the amount of rainfall. At Umudike this ranges from the last week in May to first week in July.

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Age Related Morphometric Changes of Hypopharyngeal Glands in Honeybees

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Abstract: A comparison of the morphometric changes in hypopharyngeal glands of winter and summer bees of three species of *Apis* revealed that their duct width is greater during summer, except in *A. florea*. In all the three species of *Apis* acini length was smaller during summer in comparison with winter bees and their number was greater in summer bees in all species.

Keywords: Honeybees, Hypopharyngeal glands, Age differences

INTRODUCTION

Honeybee workers perform different age related tasks during their life cycle. Winston (1987) described this phenomenon as 'age polyethism'. The hypopharyngeal glands (HGs) are important food glands and are located in the head of a worker bee. These are consisted of many pear shaped acini and are known to involve in the division of labour (Fluri *et al.* 1982), differentiation of summer and winter bees (Halberstadt, 1966), queen-workers differentiation (Jung-Hoffman, 1966); as well as worker-brood interactions (Buhler *et al.* 1983; Huang *et al.* 1989). In the early phase of their life, these produce proteinaceous secretions to nurse the brood (Halberstadt, 1980), and digestive enzymes for honey processing in the foraging phase (Simpson *et al.* 1968). Worker bees further differ in physiological and ethological characteristics in summer and winter season (Crailsheim, 1986). No information pertaining to HGs is available for the bee species of this region. Present investigation highlights some morphometric changes in these glands of three *Apis* species as related with their age and season of activity.

MATERIALS AND METHODS

This study was carried out with the worker bees of *Apis mellifera, A. dorsata* and *A. florea* species at four distinct stages of their age: nursing, comb building, honey processing and foraging. HGs of the live bees were taken out in a physiological saline (1% NaCl) and their duct width, number of acini per unit of length and acini diameter (parallel to the axial duct) were measured.

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Table 1: Mean changes in the measurements of hypopharyngeal glands in different bee species

Activity stage	*Apis mellifera*			*Apis dorsata*			*Apis florea*		
	Duct width (μm)	Acini length (μm)	No. of acini in per mm of HG	Duct width (μm)	Acini length (μm)	No. of acini in per mm of HG	Duct width (μm)	Acini length (μm)	No. of acini in per mm of HG
NB	29.4	168.5	31.9	29.4	258.3	27.5	15.0	213.8	28.5
CB	30.3	252.7	30.7	30.0	269.1	24.2	15.0	190.5	34.5
HB	30.2	249.8	32.2	30.0	281.4	27.0	15.0	190.3	35.1
FB	36.1	178.3	34.4	31.9	141.1	40.7	17.4	148.1	42.6
Overall mean	31.5	212.3	32.3	30.3	237.5	30.0	15.6	185.7	35.2

Nurse bees (NB); Comb building bees (CB); Honey processing bees (HB); Forager bees (FE)

Observations

Comparison of the morphometric changes in HGs of all the activity stages showed distinct species differences (Table 1). HGs of winter and summer bees of the three species (Table 2) revealed that their duct width was greater during summer season except in *A. florea*, where it remained almost identical in both the seasons. In all the three species, acini length was smaller during summer season in comparison to the winter bees. The number of acini was greater in summer bees than in winter bees of all the species. Data on seasonal variations in the HG measurements in *A. mellifera* further manifested significant variations in the data for both the different age groups and the season of their activity (Table 3). In nurse bees, duct width and the acini length were increased from early February and declined in early June. The number of acini recorded was highest in early April (34.8 μm). In comb building bees and the foragers, duct width increases from mid-January. Lowest acini length in foragers was recorded during early June. Correspondingly the number of acini per unit length of the gland were more during this month.

DISCUSSION

Age exerts a marked influence on HGs activity. Consequently, it provides changes in the size of acini (Rutz *et al.* 1976). The comparison of various morphometric characters of HGs of winter and summer bees showed greater duct width, smaller acini length and width in summer bees of all the three species and the acini in general had been large in the winter bees. These changes possibly corresponds to differences in their protein spectra (Halberstadt, 1966). Winter bees although with hypertrophied acini show a low rate of protein synthesis (Brouwers, 1982).

The study of ultrastructural changes in HGs (Knecht and Kaatz, 1990) further revealed that rough endoplasmic reticulum increased to the maximum during the nursing phase and decreased in field bees. In summer bees also Fluri *et al.* (1982) observed distinct changes in dry weight of HGs.

Table 2: Morphometric changes in hypopharyngeal glands of hive and field bees in winter and summer season

Season of Activity	Bee type	Hive bees				Field bees			
		Duct width (μm)	Acini length (μm)	Acini width (μm)	No. of acini in per mm of HG	Duct width (μm)	Acini length (μm)	Acini width (μm)	No. of acini in per mm of HG
Winter	*A. mellifera*	29.0	211.8	147.7	31.4	34.7	156.5	81.9	31.5
	A. dorsata	29.4	247.8	140.2	26.3	30.5	158.0	100.2	41.0
	A. florea	15.0	198.2	NR	32.5	17.4	148.1	NR	42.3
Summer	*A. mellifera*	31.2	144.5	98.8	34.3	36.0	99.4	58.1	45.9
	A. dorsata	29.5	152.0	96.5	34.0	30.8	101.5	54.6	39.1
	A. florea	15.0	104.3	74.7	38.4	20.6	82.1	45.8	39.5

NR – Not recorded
Nurse bees (NB); Comb building bees (CB); Honey processing bees (HB); Forager bees (FE)

Table 3: Age related seasonal changes in the measurements of hypopharyngeal glands in *Apis mellifera* worker bees

Activity stage		Period of observation							Cummi-lative mean
		Jan. 15	Feb. 1	Feb. 15	Mar. 1	Mar. 15	Apr. 1	Jun. 1	
NB	Duct width (μm)	30.0	26.3	27.8	29.5	30.0	32.5	31.5	29.6
	Acini length (μm)	157.5	118.8	128 9	202.5	215.8	187.5	125.2	162.3
	No. of acini in per mm of HG	32.9	30.6	31.1	30.6	31.3	34.8	33.3	32.1
CB	Duct width (μm)	28.1	30.0	30.9	32.8	30.0	30.0	30.0	30.3
	Acini length (μm)	189.4	273.2	257.2	281.3	250.8	263.9	163.0	239.8
	No. of acini in per mm of HG	31.9	31.1	29.9	33.0	28.6	29.4	32.6	31.0
HB	Duct width (μm)	29.1	31.3	30.0	30.5	30.0	30.0	32.1	30.4
	Acini length (μm)	218.8	220.0	272.5	280.0	294.2	213.2	145.4	234.9
	No. of acini in per mm of HG	32.3	33.3	29.1	30.6	36.0	32.3	35.9	32.9
FB	Duct width (μm)	33.8	35.0	37.6	40.4	35.0	35.0	36.0	36.1
	Acini length (μm)	151.0	185.6	190.1	172.3	181.0	190.0	99.4	167.1
	No. of acini in per mm of HG	30.6	30.9	31.8	35.1	30.8	39.0	45.9	36.0

Nurse bees (NB); Comb building bees (CB); Honey processing bees (HB); Forager bees (FE)

In this study, changes in the sizes of HGs in different age groups of bees are further evident with the change in season of activity. Presence of large glands in nurse bees in March month, substantiate to the fact that in this period queen and brood rearing is at peak in all the three *Apis* species. Foragers had their maximum acini size during mid February and early April, coinciding with the major nectar flow period in this region. At the early age, the hive bees are involved in broad care, their HGs are thus maximally developed to exercise maximum protein synthesis.

Robinson *et al.* (1990) also stated that juvenile hormone is responsible for reduction in size of HGs and as per the season, the JH titre reciprocate to haemolymph protein contents (Fluri *et al.* 1982).

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Biology of *Dicranognathus nebulosus* Redtenbacher (Coleoptera: Attelabidae) Infesting Oak Acorns in Kumaun Himalayas

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Abstract: The biology of *Dicranognathus nebulosus* Redt. (Coleoptera: Attelabidae) which feeds on he acorns of *Quercus leuco trichophora* A. Camus was studied in the laboratory and in the field in Kumaun Himalaya from 1985-87. Eggs were observed when seed formation started (First week of July until mid–August). The weevil has three larval instars in one generation and overwinters as third instar inside the acorn. Mean duration of the first, second and third was 26.3, 53.8 and 231.8 days, respectively. Larvae consumed the entire cotyledons after complete development. Pupation occurred inside the acorn and the pupal stage averaged 16.3 days. Generation survival was 9% in the laboratory reared weevils due to various mortality factors.

Keywords: Acorn weevil, *Dicranognathus nebulosus* Biology, and *Quercus leucotrichophora*

INTRODUCTION

The oak forest of the Kumaun Himalaya are of great importance, being used as fire-wood and in checking soil erosion. The acorns of oak in this area are frequently and mainly infested by weevils, *Dicranognathus nebulosus* Redt. and *Calandra glandium* Mshl. (Coleoptera: Curculionidae). Except for the preliminary report of Upreti and Singh (1982) on the extent of damage of acorns by insects, no detailed report is available on the life history and the real damage by this insect in the Indian oak forests. Hence the present study is a report on the biology of the weevil, *Dicranognathus nebulosus* Redt. (Coleoptera: Attelabidae) in oak forests of Kumaun region.

MATERIALS AND METHODS

The study sites

The six sites are located at and around Nainital town (29° 22′ 30″ N lat. and 79° 20′ 31″ E long.) within central Himalaya in the Kumaun region. The two oak species, *Quercus leucotrichophora* A. Camus and *Q. floribunda* occupy approximately 62% and 52% of the total area, respectively (Gupta, 1979). Ombrothermically the year in Nainital is divided into three seasons summer (March-June), rainy (July-October) and winter (November-February).

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Life cycle

The development of *D. nebulosus* from egg to adult takes place entirely within the infested acorn. Two methods were used to determine the life-cycle of the weevil. The first method was undertaken in the laboratory. In this method, mature and infested acorns were collected from the study sites and stored in the glass jars with a gauze top. Apparently healthy new adults on emergence were used to start a new colony and studies on progeny were conducted to obtain details of its biology. 50 pairs of male and female weevils were sexed and held at 20-25°C for a week before being placed in separate petri-dishes (15cm diameter) with a gauze top that contained fresh and uninfested acorns.

The second method of determining the life cycle was undertaken in one of the study sites (D. S. B. Campus, Nainital). For this five different trees were selected and acorns collected at 15 days interval were taken in the laboratory and dissected for biological data. Survival data of the acorn weevil was also recorded in this study site and was considered approximately to be the same for other study sites also.

Data collected includes adult longevity, oviposition pattern, egg viability, larval development and factors of resistance in the laboratory reared weevils and in the field conditions.

Adults

The adults on emergence were weighed, body length recorded and longevity determined. The longevity was determined by recording the dates of emergence and death for each adult.

Egg stage

All eggs laid were counted and checked daily until eclosion. Those eggs failing to hatch after 15 days were discarded.

Larval stage

One day old larvae were then transferred into the acorn cotyledons by forming a small opening into the centre and brushing the larvae into the opening with a fine brush. The cotyledons containing the larvae were then covered with acorn cup and placed at a room temperature 20-25°C. The cup was lifted daily to determine the approximate day of larval molt and larval instars. Fresh weight, larval duration, body length and width of each larval instar was also recorded.

Pupal stage

To determine pupation, acorn cotyledons were observed in between 320-357 days (period of completion of larval development) after hatch. Disruptions for each larval instar and pupae were kept minimal to reduce mortality. The causes of mortality in each developmental stage was also recorded.

Parasitism

All developmental stages were observed in the laboratory reared weevils and in field collections for parasitoids.

Table 1: Duration and measurements of stages of laboratory reared weevils, *D. nebulosus*

Growth Stage	Number observed (n)	Developmental period x (range) days	Measurements immediately after each molt weight (mg)	Body length (mm)	Body width (mm)
Egg	40	10.5±0.5 (9-12)	N.A.	0.5±0.001	N.A.
I Instar	50	26.3±0.5 (24-28)	1.6±0.3	0.8±0.07	0.25±0.05
II Instar	40	53.8±0.6 (48-56)	5.6±0.9	1.9±0.06	0.60±0.08
III Instar	36	231.8±5.6 (225-240)	22.4±1.5	5.4±0.19	1.70±0.12
Pupa	40	16.3±1.5 (15-20)	N.A.	3.5±0.5	1.40±0.2

(Mean ± SE)

RESULTS

Egg stage

The eggs were translucent, creamy white in colour and oval in shape. The female weevil made a puncture with the help of her mandibles located at the tip of the proboscis and deposited a single egg per acorn (n=200). The area of puncture eventually turns black. Acorns weighing less than 0.2±0.02a (mean+SE) did not contain any egg (n=115). Ten weevils were observed with ovipositor inserted, a position that lasted 20.2+4.8 min. (mean±SE).

Larval stage

The larvae are legless, wringled, creamy to yellowish grub with brownish head capsule. The larvae began feeding on the cotyledons immediately after hatching, and within a few days, a small gallery was found extending short distance from the point of oviposition. The first instar larvae fed on the outer surface of the cotyledons while subsequent instars fed within the cotyledons. By the time they were fully developed the endosperm is completely reduced to a yellow-brown granular frass. Mature larvae pupated inside the acorn.

Pupal stage

The pupa is white with a slight creamy cast and distinct black eyes. The rudimentary appendages such as legs and wings are compressed against the sides of the body. The proboscis is folded beneath but it is free, and tips rest on the ventral side of the body. The pupal stage is highly sensitive and measurements were based on a small sample (n=20) so as not to interfere with their development.

Adult stage

Following transformation from pupal stage in the acorn, there is a resting stage of 15-20 days. The weevils undergo a change during this resting period stage. The exoskeleton hardens and the colour changes from yellow to grey, and the internal organs of the insect mature.

Table 2: Biological data for laboratory reared *D. nebulosus* adults

Feature	Number (n)	(Mean + S.D.)
Male body length (mm)	26	10.76±0.09
Female body lenfth (mm)	16	11.38±0.48
Length of male proboscis (mm)	10	3.44±0.14
Length of female probosics (mm)	12	4.16±0.23
Weight of male after hatching (mq)	74	14.80±0.71
Weight of female after hatching (mq)	114	16.10±0.85
Pre-obviposition period (days)	34	16.30±0.42
Oviposition period (days)	40	64.70±4.96
Male longevity (days)	28	31.50±2.93
Female longevity (days)	28	44.70±1.36

The adults emerge from the acorns by chewing an exit hole from the inside of the shell with the mandibles. The exit holes vary in size from 1-2 mm. Emergence of laboratory reared weevils started on in the last week of June and continued until first week of September. Biological data of the adults are summarised in Table 2. The females were slightly longer and heavier than the males but differences were not significant. In the laboratory reared weevils, it made no difference whether food and water were supplied as the duration of adult life was approximately same for starved or fed weevils. Thus feeding is not absolutely essential to their survival.

The females did not lay eggs earlier than the 16th day after emergence from the acorns. Thus the time between emergence and oviposition was considered to be pre-oviposition period (16 days).

Mating was observed only in the laboratory, where adults were kept in the petri-dishes with a guaze top, Mating time (from mounting to cessation) varied from 5-60 min.

Weevil survivorship in the laboratory

The percentage mortality in different stages of development in the laboratory reared weevils is given in Table 3. Approximately 34% of the eggs failed to hatch. With three species of fungal hyphae viz. *Aspergillus niger* Van Teighem, *Cordana musae* Zimm. Hohnel and *Penicillium chrysogenum* Thom. accounting for one of the reasons. Developmental failure accounted for heavy mortality of mainly first and second instar larvae. A small percentage of larvae failed to transform and failed to emerge from acorns as adults. The estimated survival from egg to adult stage is 9% (Table 3).

DISCUSSION

Life history

Literature on the life history of acorn weevils are only a few. According to Brooks (1910) some weevils deposit only one egg per acorn, others construct branched cavities in which a dozen eggs are deposited. Chellman (1954), reported that usually one

Table 3: Life table for the laboratory reared acorn weevil, *D. nebulosus* adults

Stage	% Mortality	Factors
Egg	34	Infertility, fungus, developmental failure
Larva	54	Fungus, dessication, developmental failure
Pupa	02	Failure to transform
Adult	01	Failure to emerge from acorns

egg is deposited in an acorn of *Quercus virginiana* Miller if the puncture is extended to the cotyledons and as many as seven eggs may be deposited if the puncture extends into the cotyledons (average 1.92 eggs per acorn). *Curculio* sp. deposits a single egg in each hole of the acorn (Solomon *et al.* 1980). The weevil, *Curculio arakawi* Matsushima and kono deposits several eggs into the fresh tissue of the acorn of *Quercus serrata* Thunb. (Matsuda, 1982). *Curculio fulvus* Chittenden laid 0-6 eggs with a mean of 3.4±0.91 eggs in acorns of *Q. virginiana* (Oliver and Chapin, 1984). In comparison, *D. nebulosus* laid one egg per punctured acorn of *Quercus leucotrichophora* (Present study).

The number of larvae emerging from acorn also varies in different weevil species. Mitchell and pierce (1911), reported that 266 larvae emerged from 167 live oak acorns. Chellman (1954), reported as many as 5-14 first instar larvae in one live oak acorn indicating an attack by more than one adult of the same acorn but only one mature larva emerged from the acorn. The emergence of only one larva from the acorn despite presence of many larvae suggests the possibility of cannibalism. Brenzner (1960) indicated that acorn size influence the number of larvae surviving per acorn, but the size of the acorn was not a factor for all species. Acorns of *Q. rubra* infested by *Curculio* sp. normally contains 2-5 larvae (Gibson, 1982). Matsuda (1982) reported that 1-2 qrubs of *C. arakawi* emerge from an acorn of *Q. serrata*. Oliver and Chapin (1984) observed two different stages of larvae of *C. fulvus* in an acorn of *Q. virginiana* indicating two attacks by adults. They further reported that an average of 2.24±0.48 larvae developed per infested acorn through the last instar. Only one larva developed per infested acorn and the larval survival appeared to be unrelated to acorn size in the present study.

Wenzel (1905), Blatchley and Leng (1916), Brooks and Cotton (1929), chellman (1954) and Brenzner (1960) have also reported that fungi, birds and insectivorous mammals take a heavy toll of developing acorn weevil larvae, thus controlling weevil population.

Braconid wasps (Hymenoptera: Braconidae) and Dipteran mainly Tachinidae, cause mortality of acorn weevil larvae when they are exposed for a brief period during borrowing into the soil for pupation or in the prepupal stage in the larvae do not leave the fruit (Blatchley and Leng, 1916; Brooks and Cotton, 1929; Chellman, 1954; Brenzner, 1960; Gibson, 1969, 1982 and Steven, 1981). They, however, further reported that mortality caused by parasitoids did not affect acorn infestation. Since larvae of *D. nebulosus* complete their development entirely inside the acorn, and are thus not exposed to parasitoids.

The approximate survival of *D. nebulosus* in the field conditions (5%) is almost similar to 4% in *Curculio* sp. reported by chellman (1954). However, the approximate survival in the laboratory reared weevils (9%) in the present study is considerably lower to 8-20% for a few other seed eating beetles and curculionids (Dickason, 1960; Parnell, 1966; and Mitchell, 1977).

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Pests of Fruit Crops In Andaman and Nicobar Islands

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Abstract: Twenty six insect pests, a mite and a mammal pest are being reported on 13 fruit crops from these islands for the first time. Parasites have been reported on some of these pests. One mammalian pest-a civet cat-is being reported as a serious pest on fruits of pineapple and papaya

Keywords: Fruit crops, Insect, mite civet cat, Andaman Nicobar islands

INTRODUCTION

The Andaman and Nicobar islands, have no air or sea contact with any part of the world other than mainland India, from which it is separated by a distance of about 1200 km. Situated in the North eastern Indian Ocean these islands lie between 6-14°N latitude and 92-94°E longitude. They were colonised for the first time by the British for a period of about seven years between 1789-1796 after which the islands were abandoned for over 60 years before being reoccupied in 1858. It was during this period that a number of plants, including many fruit crops were introduced to these islands (Prain, 1890). Even today however, the islands rely heavily on imports from the Indian mainland to meet the requirement of fruits for a population of only 2.96 lakhs of people. Banana, which is being cultivated in 1407 ha. is the most extensively cultivated fruit crop of these islands, followed by papaya which occupies a mere 241 ha. (Anon., 1991). All other fruit crops are grown as components of homestead gardens on a very limited acreage. In the days to come when fruit crops receive their due share of importance on these islands, insects will prove to be a major impediment to production. We therefore studied the occurrence of insect pest on the fruit crops being cultivated here. Earlier studies revealed a total of 67 species of insects belonging to four orders and 34 families attacking 11 different fruit crops (Belavadi and Shah, 1987; Bhumannavar, 1989, 1990; Bhumannavar *et al.* 1991; Veenakumari and Prashanth Mohanraj, 1991).

During the course of an ongoing study to document the pest complex of crops on these islands many more species of insects were found attacking fruit trees, some of which are being recorded for the first time.

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MATERIALS AND METHODS

Homestead gardens and farms in the various localities of South Andaman were visited at weekly intervals and searched visually for the presence of insects. The immature stages of all insects found feeding on fruit crops were brought to the laboratory and reared to adulthood on their respective fruit plant hosts. The adults so reared were preserved and sent to the Natural History Museum, London and the International Institute of Entomology, London for establishing their identities.

RESULTS AND DISCUSSION

The insect pest of fruit crops, the nature of damage on their respective host plants and their natural enemies in the Andaman and Nicobar islands are given in Table 1. While some of these species occur on the same crops, others have been reported to attack alternate host plants in mainland India (Bhutani, 1979; Chowdury and Majid, 1954; David and Kumaraswami, 1978; Fletcher, 1920; Misra, 1920; Oommen, 1962; White and Elson-Harris, 1992).

Table 1: Insect pests and their natural enemies on fruit crops in the Andaman and Nicobar islands

Taxa	Life history stages	Part(s) of plant attacked	Natural enemies
LEPIDOPTERA			
Thyrididae			
Banisia myrsusalis elaralis (Walker)	Larva	Leaf webber of sapota	–
Gelechiidae			
Hypatima sp.	Larva	Young leaves of sapota	
Anarsia sp.	Larva	Bud borer of sapota	*Phanertoma* sp. (Hymenoptera)
Lyonetidae			
Lyonetia sp.	Larva	Leaf miner of sapota	*Teleopterus* sp. (Hymenoptera)
Immidae			
Imma tyrocnista Meyrick	Larva	Young leaves of sapota	–
Totricidae			
Cellifera cellifera (Meyrick)	Larva	Leaf, webber of jamun	*Eupelmus* sp. (Hymenonptera)
Homona permutata Meyrick	Larva	Leaf webber of jamun	–
H. eductana Walker	Larva	Leaves of citrus	–
Noctuidae			
Achaea janata	Larva	Defoliator of pomegranate	–
Cerynea contentaria	Larva	Fruits of rose	–

Walker		apple	
Pyralidae			
Diaphania caesalis (Walker)	Larva	Fruit borer of jack fruit	–
Phostria flocculentalis Hampson	Larva	Leaves of custard apple	–
Phycita erythrolophia Hampson	Larva	Young buds of sapota	–
Synclera univocalis Hampson	Larva	Leaf roller of ber	–
Geometridae			
Hyposidra talaca Walker	Larva	Defoliator of gauva	–
Hyposidra sp. probably *infixaria* Walker	Larva	Defoliator of gauva	
Lasciocampidae			
Lebeda sp.	Larva	Defoliator of gauva	–
Limacodidae			
Parasa sp.	Larva	Leaves of mango	–
HOMOPTERA			
Aphididae			
Aphis gossypii complex	Adults and nymphs	Shoots and leaves of gauva	–
Coccidae			
Saissetia coffeae (Walker)	Adults and nymphs	Shoots of sapota	–
Coccus viridis (Green)	Adults and nymphs	Shoots of sapota	–
Icerya seychellarum (Westwood)	Adults and nymphs	Shoots of sapota	–
HEMIPTERA			
Tingidae			
Stephanitis typica (Distant)	Adults and nymphs	Leaves of banana	–
COLEOPTERA			
Attelabidae			
Cerynea contentaria Walker	Adults	Leaves of star apple	–
DIPTERA			
Tephritidae			
Bactrocera carambolae Drew & Hancock	Larva	Fruits of guava, rose apple, star apple	–
B. (Zeugodacus) cucurbitae Coquillett	Larva	Fruits of watermelon muskmelon	–
ACARINA			
Tetranychidae			
Eutetranychus sp.	Adults and	Leaves of papaya	–

	nymphs
MAMMALIA	
Felidae	
Paguma larvata tytleri (Civet cat)	Feeds on fruits of pineapple, papaya

Some are known to be serious pests of crops, including non-fruit crops. For instance, *C. viridis* causes more damage in citrus and coffee than on sapota, while *I. seychellarum* has the potential to become a serious pest of citrus, even killing the trees at times (G. W. Watson, IIE, Colln., No. 22051).

The Andaman Palm, Civet is confined to the Andaman islands and is the only known carnivore on these islands. It however, also feeds on a variety of cultivated and non-cultivated fruits. Being nocturnal in habit it inflicts damage by biting off large chunks from fruits in the night.

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Three New Species of Mites Associated with Insects from Tamil Nadu, India

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Abstract: The paper presents the descriptions and illustrations of three species of mites new to Science, namely *Caloglyphus phyllagnathae* sp. nov (Acaridae: Acarina) phoretic on the beetle *Phyllagnathus dicnysius* (Dynastidae: Coleoptera) *Lepidoglyphus combus* sp. nov (Glyciphagidae: Acari) associated with stored old comb of *Apis florea* and *Tyrophagus debrivorus* sp. Nov (Acaridae: Acari) isolated from old comb materials of *Apis florea* (Apidae: Hymenoptera).

Keywords: *Caloglyphus; Lepidoglyphus; Tyrophagus,* Acaridae; Glyciphagidae, Insect associated mites.

INTRODUCTION

The family Acaridae is a large assemblage of saprophagous graminivorous, fungivorous and phytophagous mites which may be found from extremely wet to fairly dry habitats, generally feeding on organic debris of plants or animals. The acarids may be free living, associated with insects or found in the nests of small mammlas (Hughes 1976). The species of *Caloglyphus* may occur in food storages or soil litter (Hughes 1961) or occurs as a saprophage in soil. The species of *Tyroghagus* is a common contaminant of stored products which because of its astonishing fecundity is a cause for concern in laboratory insect culture. A species of *Tyrophagus* has been implicated as the causal agent in cases of human intestinal and urogenital acariasis (Krantz 1975). The specieis of the family Glycyphagidae also occurs in stored products (Hughes 1961) which have been also reported to occur in the nests of rodents (Fain 1968). During the course of investigation on the mites associated with insects a number of new species were encountered. This paper describes two species of mites under the family. Acaridae and one species under the family Glycyphagidae, isolated from Dynastid beetle and comb material of *Apis florea*, which have been adequately sketched and described. All the measurements given are in microns. The types and para type slides are deposited in the Acarology collections of the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore 641003, India.

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***Caloglyphus phyllagnathae* sp nov. (Fig. 1 to 4).**

Hypopus:

The hypopus measures 304 long and 203 wide. The dorsum of hypopus is somewhat elongate with distinct propodosoma having two pairs of small setae (5 long), and the hysterosoma with seven pairs of small setae, caudal pairs of setae (10 long) at the posterior end of dorsal sclerite. Just below the anterior margin of the hysterosomal shield, wavy striations are distinct, otherwise no patterns or punctations are seen.

Venter:

Setation is vey limited on the ventral shield, only four pairs of setae are present but somewhat longer, than the dorsal setae. the ventral caudal setae is 24 long. The dorsal plate is as figured and quite distinct from the Anoetid groups. Gnathosoma is represented by a sub capitulum (16 long by 12 wide) and a pair of palp (8 long) and a pair of seta (34 long). The setae d_2 is 7 long, whereas the setae elcp is 4 long. The apodemes of the legs I and II are open while III and IV are closed; on the ventral side, just by the side of III pair of legs a pair of dark pigmented area is observed which is unique in this species.

Legs:

Legs bear some specialized structures also, apart from usual setaceous setae. The coxae I to IV bears a setae each, with a prominant spur, Leg-I (120 long) with a coxal setae (10 Long), Tarsi I bears many specialized setae (20 long) and 2 pairs of empodial rods (20 long) with lanceolate tip. Tarsus also bears setae ω_1 (omega) 10 long and ω_2 7 long, besides Condylophore (5 long) and ends in an empodial claw (10 long). Leg II (106 long) with a prominant spur (4 long) and a coxal setae (10 long), as in the first pair of legs. The tarsus bears all the specialized structures as in the first leg but with one pair of empodial rods (20 long). Leg III and IV (90 and 80 long) lack any other specialized structures excepting a condylophore on the tarsus (5 long) and empodial rods.

Types:

A holotype marked on the slide along with two more hypopi dutonymphs: India: Tamil Nadu: Coimbatore, 21.XI.1988 ex-*Phyllagnathus dicnysius* (Dynastidae: Coleoptera) coll. C. Chinniah (No. 21/3) and 2 paratype slides with hypopi, collection data same as that of holotype.

Diagnosis:

The new species resembles *Caloglyphus berlesei* (Michael 1903) in general facies, dorsal chaetotaxy, and some of the leg setal characters, but it differs from the structure of apodemes and also the ventral sucker plate structre. Subcapitulum also is some what short (16 long) compared to *C.berlesei.* Moreover a pair of dark pigmented patch on the ventral side just by the side of III rd pair of legs is very unique in the new species.

Figures 1 to 4: *Caloglyphus Phyllagnathae* sp. nov. 1. Dorsal view of Hypopus 2. Ventral view of Hypopus 3. Legs I-IV 4. Gnathosoma

Relationship to the host:

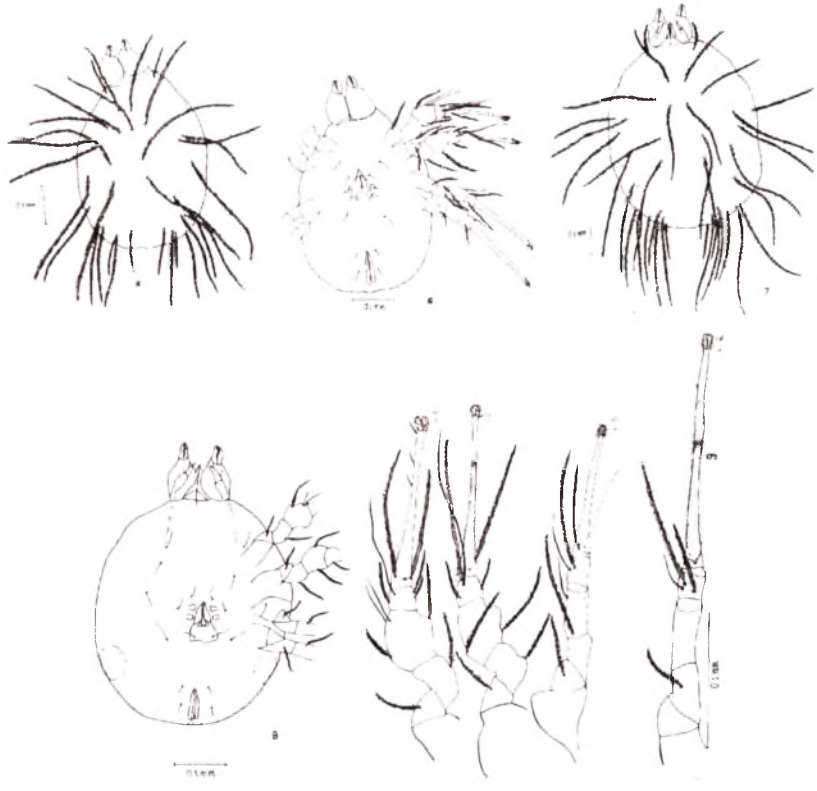
The hypopi of these straw-yellow colored mites were found firmly attached to the venter of abdominal region of the host beetles collected from light traps. All the mites studied were hypopi with reduced gnathosomal structures, well developed ventral sucker plates and specialized leg characters that are meant for phoresy and hence the relationship is purely phoretic.

Lepidoglyphus combus sp. nov. (Fig. 5 to 9)

Female: Adult mites with long densely pectinare dorsal setae with a body size of 404 long and 310 wide. The setae present on the propodosomal region are relatively shorter (200) than the opisthosomal setae (400) generally. The sub capitular setae is comparatively less densely pectinate and probably shortest (75 long) among the dorsal setae. The entire dorsum is covered by very fine and minute projections that are very prominant at the posterior especially around the anal slit. The opisthosomal setae are as long as 400 excepting a few.

Ventrum has a minimum number of 8 pairs of smooth spine like setae. The genital setae arranged as figured (24 long) and the two pairs of anal setae are 47 long. The apodemes of coxae I to IV are not so prominant and they are free. The female genital structure situated near the coxae III. In many of the specimens examined, eggs were encountered in the opisthosoma of female (122 long and 79 lide). Gnathosoma is slightly broader (104), than long (94), the chela on the cheliecerae have strong tooth and always bidentate.

Legs: Legs I to IV always have long tarsi more than thrice as long as the adjoining tibiae with an unsclerotized fleshy caruncle with a small empodial claw. All the leg setae are fairly pectinate excepting a pair of smooth setae on the genua I (52 long) and tibiae I (104 long). In other legs II-IV each a long smooth seta is present either on tibia alone or tibia and tarsus. The length of legs I-IV are 258, 289, 287, 329 respectively. Each tarsus is enveloped in a pectinate subtarsal scale-which is attached at the base, which in its natural position, gives the tarsus a ciliated appearance.



Figures 5-9 *Lepidoglyphus combus* sp. Nov. 5. Dorsum of adult female 6. Ventrum of adult female 7. Dorsal view of adult male 8. Ventral view of adult male 9. Legs I-IV (Adult male)

Male: Adult male is almost equal in body size (876 long and 329 wide) as that of female with long strongly pectinate dorsal body setae. The subcapitualr setae is 70 long as in the female; other dorsal chaetotaxy is as figured and almost similar to that of female. The apodemes of coxae I to IV are free and not fused. The ventral setae are comparatively small and smooth. The male genital structure arranged between the coxae III and IV with 3 pairs of genital setae (28 long). The aedeagus is slightly 'S' shaped and 47 long. The anal structure is a vertical slit. Just below the coxae IV the latero abdominal glands are large and in life, coloured blood red, however this colour fades in Hoyser's medium, found both in male and female adults.

Gnathosoma: Ganthosoma 103 wide and 98 long with bidentate chela. The palp is not so distinct, neverthless the segments could be observed with a few pairs of setae.

Leg: Leg characters and chaetotaxy as figured and are similar to female. The length of Legs I to IV, 277, 280, 286 and 329 respectively.

Types: A holotype female and an allotype male marked on the slide, India: Tamil Nadu: Coimbatore, 25.1, 1988; ex. *Apis florea* (Apidae: Hymenoptera) Coll. C.

Chinniah (No. 13.4): four paratype slides with males and females, collection data as type.

Diagnosis: This new species is similar to *Lepidoglyphus destructor* Schrank in general facies and chaetotaxy but differs in many attributes like the body size, number of dorsal and ventral setae, structure and arrangement of ventral apodemes and leg chaetotaxy, other characters are typical to the genus. This new species lacks christometopica (four in *Glycyphagus*) and hence it has been included in the genus *Lepidoglyphus* which was erected by Zakhvatkin (1936), later in was recognized as a separate genus by Cooreman (1942) also.

Relationship to the host: Dull colored mites with dense hairy body were isolated from the stored, damaged, comb of *Apis florea*. These mites were observed to feed actively and reproduce well on the comb material and thus it is likely to be a feeder of organic material probably this would be the first report of a glycyphagid mite associated with bees from India.

3. Tyrophagus debrivorus sp nov. (Fig. 1 0-14)

Female: Soft bodied and white colored mites with a body size of 540 long including gnathosoma and 270 wide. The dorsum of female has a propodosomal shield which is not so distinct. The dorsal body setae are long, smooth or weakly pectinate. Just above the propodosoma a pair of weakly pectinate setae (15 long), are present and so also to the lateral side of the propodosomal shield (18 long). Just below the propodosomal shield also a pair of pectinate setae are present, the outer pair 94 long and the inner pair about 103 long. The dorsal setae on the hysterosoma is smooth, weak (15 long), excepting the dorsolaterals which are fairly long (150 long) and are very sparsely pectinate to smooth. All the dorsal setae on the posterior of opisthosoma are long (235 long) and weakly pectinate.

Venter: The apodemes of coxae I to IV are prominat and the coxal fields of all the four pairs of legs bear a pair of inter coxal setae (10 long); other ventral setal patterns of females as figured. The genital opening of female lying anterior to coxae III and extending posteriorly to coxae IV with two pairs of genital setae arranged as figured. The anal opening is elongate wavy with four pairs of small, smooth and short setae. During the observation in most of the cases eggs were encountered in female (40 long and 26 wide).

Gnathosoma 86 long and 60 wide at the base; bears a pairs of short chelicerae and the chela, many toothed, gnathosoma also bearing two pairs of slender setae.

Legs: Let I (180 long) bearing a short setae (15 long) on the trochanter and the seta on tibia is long (75) and setaceous; tarsi I, 10 long, bears a short seta (ω) which is tapering and ends in an unsclerotized empodial claw (8 long) leg-II also has all the characters as in leg I excepting the setae (ϕ) which is a bit longer (80). The length of leg III and IV is 186 and 206 long respectively.

Male: Similar to the female in general facies and setation excepting the genital structure with a size of 376 long by 178 wide. Male also has a propodosomal plate and the dorsal chaetotaxy as figured.

Figures 10 to 14 *Tyrophagus debrivorus* sp. nov. 10. Dorsal view of adult female 11. Ventral view of adult female 12. Dorsal view of adult male 13. Ventral view of adult male 14. Legs I-IV (Adult male)

venter: In between the coxae II and III a prominant lyri fissure is observed as in female. The genetalia lying between coxae IV; with two pairs of small genital setae (8 long). Gnathosomal characters very similar to female.

Leg chaetotaxy and other characters are almost same as that of female excepting the length of setae ω (10 long) and setae ϕ (80 long) on tarsi I and ω 13 long and ϕ 85 long on tarsi II.

Hypopus:

Unknown

Type: A holotype female and allotype male adults marked on the slide: India: Tamil Nadu: Yercaud 5. V. 1988. ex. *Apis florea*: Coll C. Chinniah (no 32/10) Ten paratype slides, collection data same as holotype.

Diagnosis: This new species of mite is similar to *Tyrophagus similis* volgin. in general characters, dorsal chaetotaxy, and the presence of propodosomal shield but differs in many ways. The propodosomal shield is not so distinct both in male and

female as in *Throphagus similis*. Body size also varies, the solenidion on the tarsi I and II do not have an expanded tip as in *Tyrophagus similis*.

Relationship to the host: The soft bodied, white colored mites with long setae on the body were found to be actively feeding and breeding on the stored old comb material of *Apis florea* and females were found but not a single hypopus. In all the cases it has been reported from the comb material Husband (1968) has reported *Tyrophagus putresentiae* from bumble bees. Michigan and Dejong *et al.* (1982) have reported the same from comb of *Apis* sp. From the investigation it is clear that the mites are feeding on the comb material and carried by the bees.

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Studies on Feeding Behaviour of Leafminer *Chromatomyia horticola* (Gour.) in Selection of Host Plants

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Abstract: Studies on feeding behaviour and ovipositional preference by adult females when offered a choice of six acceptable plants show that maximum number of feeding punctures were only on the plants from which flies were bred. The number of feeding punctures on *Brassica campestris* L was significantly higher than on other plants tested. The number of feeding punctures on *Raphanus, Eruca, Helianthus* and *Chrysanthemum* were not significantly different from each other, but were significantly lower than on *Brassica* species. The number of punctures with an egg on *Brassica, Raphanus, Eruca* and *Helianthus* were not significantly different from each other, but were significantly higher than on *Chrysanthemum* and *Tropaeolum*. No relationship was found between the number of ovipositional punctures and the number of feeding punctures.

Keywords: Feeding behaviour, ovipositional preference, *Chromatomyia horticola*

INTRODUCTION

Chromatomyia horticola (Gour.) is a leafminer which tunnels into the leaves and a oligophagous agromyzid pest, whose members feed in nature around the Agra region, India, only on the representatives of the cruciferae, compositae and tropaelaceae. The plant species attacked are *Brassica compestris* L., *Raphanus sativus* L., *Eruca sativa* L., *Helianthus anus* L., *Chrysanthemum* sp. (Cultivated variety), *Tropaeolum majus* L. (Wild variety) as hosts for the members of this species. However, the identity of flies bred from some of these hosts probably needs confirmation by examination of the male genitalia. Studies on various aspects of host selection, feeding an host preference in phytophagous insects has been reviewed by many authors (Lipke and Fraenkel, 1956; Friend 1958; Thorsteinson 1960; Kennedy 1965; Deithier 1970 and Singh *et al.* 1986).

Most research in the field of insect host plant relationship has been on external plant feeders. Agromyzids having evolved as exclusively internal plant feeders are more closely bound to plants than any group of external feeders and are therefore ideal for the study of insect food plant relationship. The female agromyzid deposits an egg individually inside the tissue of a selected plant. The emerging larva, unlike that of external plant feeders, is unable to select a more suitable food plant which

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might be available in its ecological range. The larva either feeds on the plant tissue selected for it by its mother and dies. Although an agromyzid larva is not concerned with the selection of a suitable food plant, it is directly involved with its acceptance. These larvae are therefore most suitable for the study of their potential to use various food plants for their development.

The studies on behaviour of host plant selection of leafminer, *Chromatomyia horticola* (Gour.) is inadequate, therefore present study is very essential.

MATERIALS AND METHODS

Small twigs of every six plant species, bearing young leaves, were exposed individually to five gravid females inside a muslin cage, for a period of 24 hours. At the end of the experiment, flies were free moved from the cages and the leaves examined for feeding punctures and punctures with eggs.

A circular plastic petri-dish 5 1/2 inches in diameter was used as a choice chamber to test the feeding and oviposition preference of adult females. The young leaves of six different plants, grown under laboratory conditions, were placed periphery of dish equidistant from one another. The petioles of the leaves were pulled out through small holes in the periphery of the dish and wrapped with cotton kept moist with distilled water. The plant used in this experiment were *Brassica campestris* L., *Raphanus sativus* L., *Eruca sativa* L., *Helianthus anus* L., *Chrysanthemum* and *Tropaeolum majus* L. (cultivated variety). Five gravid females from laboratory culture maintained on *Brassica campestris* L. were used in each test after being isolated from their food plant for one hour. They were anesthetized with CO_2 and then introduced to the centre of the petridish.

RESULTS

The preference of gravid females for feeding and oviposition when offered a choice of six acceptable plants was examined. (Table 1).

The number of feeding punctures on *Brassica campestris* L was significantly higher than on other plants tested. The number of feeding punctures on *Raphanus, Eruca, Helianthus* and *Chrysanthemum* were not significantly different from each other, but were significantly lower than on *Brassica*. The number of punctures with an egg on *Brassica, Raphanus, Eruca* and *Helianthus* were not significantly different from each other, but were significantly higher than on *Chrysanthemum* and *Tropaeolum*. No relationship was found between the number of oviposition punctures and number of feeding punctures.

Feeding preference by freshly emerged females which has not been exposed to any food plant was examined in a similar experiment (Table 2). The only difference from table 1 is that the number of feeding punctures on *Raphanus sativus, Eruca sativa* and *Helianthus anus* were significantly higher than on *Chrysanthemum* and *Tropaeolum*.

When females were offered a choice of six acceptable plants for feeding and oviposition, *Brassica*, from which the flies used were obtained, was most preferred for feeding (Table 1); however, the number of eggs laid were not significantly higher than on some other plants in the test. In another experiment in which freshly emerged

Table 1: Feeding and oviposition preferences of female *Chromatomyia horticola* (Gour.) from a culture raised on *B. campestris*

Test plant	Average number of feeding punctures	Average* number of punctures with an egg	Index of suceess	Index of plant relationship
Brassica campestris	519.5 a**	11.8 'a	1.000	10
Raphanus sativus	200.5 b	13.3 'a	0.756	8
Eruca sativa	181.6 b c	10.5 'a	0.614	8
Helianthus anus	161.0 b c	15.0 'a	0.790	8
Chrysanthemum sp.	58.5 b c	2.3 b'	0.153	7
Tropaeolum majus	36.8 c	1.6 'b	0.102	8

*Averages are based on six replicates
**Treatments which are not significantly different from each other have the same letter opposite; as calculated by Duncan's multiple range significance level test.

Table 2: Feeding preferences of freshly emerged (< 24 hours) females of *Chromatomyia horticola* (Gour.) from *Brassica campestris*

Test plant	Average number of feeding punctures*
Brassica campestris	250.8 a**
Raphanus sativus	174.6 b
Eruca sativa	139.5 b
Helianthus anus	128.6 b
Chrysanthemum sp.	28.3 c
Tropaeolum majus	14.3 c

*Based on six tests.
**Treatments which are not significantly different from each other have the same letter opposite; as calculated by Duncan's multiple range significance level test.

females obtained from pupae bred on *Brassica* were used, *Brassica* was still most preferred (Table II) in number of feeding punctures.

DISCUSSION

The preference of feeding on *Brassica* may either be explained by the preconditioning in their larval life as defined by Hoppin's (1971) host selection principle or by the greater quantity of substances which stimulate feeding, or just by the taste preference of the females. This however, can not be clarified at present and would need further detailed studies. However, behaviour in which insects prefer the plant species previously eaten, is in agreement with the observations of Jermy, Hanson and Deithier (1968) on *Manduca sexta* (Johanseen) and *Heliothis zea* (Boddie). It may be pointed out that *Brassica* appeared to be more heavily attached in nature than other host plants. This, however, may also be due to various other factors like greater

abundance of this plant in the habitat.

Among other plants used in the study *Raphamus, Eruca* and *Helianthus* were almost equally preferred, while *Chrysathemum* and *Tropaeolum* were least preferred for both feeding and oviposition (Table I, II). The first three plants belong to the same tribe cruciferae as *Brassica* and also serve as host plants in nature. In *Raphanus*, only the soft leaf variety was found to be attached in nature. This suggests some importance of physical characteristics of plants in their selection of behaviour. *Tropaeolum* not closely related to *Brassica*, was not preferred, probably because the leaves used had a thick covering of wooly fibers on their lower surfaces, which may act as a physical barrier for females of this species. *Chrysanthemum* which was also not preferred, is not as closely related to *Brassica*. It was also not found to be attacked in nature.

Hussey and Gurney (1962) suggested the use of feeding punctures to egg ratio as a method of assessing host preference in agromyzid species. The most preferred host plant would have the lowest feeding punctures to egg ratio. They worked with a polyphagous species *Phytomyza atricornis* Meigen which was later shown by Griffiths (1967) to consist of two distinct species *Phytomyza syngenesiae* (Hardy) feeding predominantly on composits and *Phytomyza horticola* Goureau, feeding on composits and other families so that their results can not be properly evaluated. In the populations used they found that feeding puncture to egg ratio was lower on preferred plants and concluded that preferred plants are nutritionally superior. It appears that the differential feeding and oviposition in their experiments with different varieties of *Chrysanthemum* was due to chemical factors which act as stimulants or deterrants rather than to nutritional preferences. The majority of species in the family Agromyzidae are restricted feeders being monophagous or oligophagous (Sehgal 1971). However in the present study *Chromatomyia horticola* (Gour.) selects Botanically related plants for feeding and oviposition in the nature. Restricted feeding in nature on botanically related plant species or on unrelated plant species having similar secondary substances is probably the result of evolutionary coadaptations of the phytophagous insect to the allelochemics (Whittaker and Feeny 1971), allomones and kairomones, of the plants.

Therefore, it is concluded that host preference was determined not only by the presence of adequate feeding stimuli and nutrients, but also by the presence of host specific substances which induce the initial feeding behaviour.

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Effect of Temperature on the Activity of Amylase in Silkworm *Bombyx mori* L.

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Abstract: The multivoltine (C-nichi) and bivoltine (KA) strains of silkworm *Bombyx mori* were reared at two different temperatures, including high (33±1°C) and normal (25 ± 1°C). The activity of amylase in response to temperature was studied in haemolymph and midgut tissues of IV and V instar. The amylase activity was high and the period of larval life was reduced in the larvae reared at 33°C when compared with the larvae maintained at 25°C. The peak activity of amylase was in the beginning and middle part of the each instar at 33°C and 25°C respectively. It is concluded that high temperature (33°C) had an adverse effect on the activity of amylase especially in KA strain.

Keywords: temperature, amylase, *Bombyx mori*, strains.

INTRODUCTION

In silkworms temperature plays a decisive role in the determination of the rate of development, mortality, fecundity and voltinism, since they are poikilotherms. Effect of temperature on certain metabolites of silkworm and heat tolerance with reference to racial differences were extensively studied by several authors (Shen, 1986; Suzuki and Ueda, 1987; Madhurar and Rao, 1989; Patil and Visweswaragowda, 1986). Matsumura (1928) sought a relationship between the physiological activity and the optimum temperature, by determining the optimum temperature of physiologically important enzymes. With regard to amylase, the activity increased with the rise of temperature from 20°C to 60°C.

Amylase is one of the key enzymes involved in digestion and carbohydrate metabolism in insects (Daone *et al.* 1976; Horie and Watanabe, 1980). Amylase obtained from different origins have been characterised (Fisher and Stein, 1960; Takagi *et al.* 1971; Baker 1983, 1987, 1989, 1991). In the silkworm, *Bombyx mori*, Yokoyama (1959) reported the presence of two types of amylase activities in the digestive fluid and haemolymph. Kanakatsu (1972) purified amylase of the digestive fluid and studied its properties (Ito *et al.* 1962; Kanakatsu, 1978). Abraham *et al.* (1992) identified different series of amylases in both diapausing and non-diapausing strains. Banno *et al.* (1984) studied sexual dimorphism and developmental changes in haemolymph amylase of *B. mori*.

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Materials and Methods

The silkworm strains used for the present study included, C-nichi (multivoltine) and KA (bivoltine). The egg layings obtained from the breeding station of Karnataka State Sericulture Research and Development Institute, Bidadi, Government of Karnataka, were maintained in the environmental chamber (Cuboidal Chamber made of two layered aluminium sheets packed in between with thermocol and with a door on one side, size 76.5"×76.5"×76.5") fabricated for this purpose, wherein any one of the environmental factors viz. temperature, humidity, or light can be varied in the chamber. However, other factors can be kept constant/optimum for larval growth. The races were subjected to two different temperatures viz. High (33±°C) and normal (25±°C) and relative humidity of 80% maintained throughout the rearing period. The rearing methods are similar to that of method followed by Krishnaswami (1978).

Haemolymph and midgut tissue were collected every day from the first day of the IV instar upto the onset of spinning. Haemolymph was collected in precooled 5ml tubes containing few crystals of phenyl thiourea. The midgut was separated from the rest of the alimentary tract, flushed with ice–cold *Bombyx* saline to make free of leaf debris and stored in crushed ice (Yamaoka *et al.* 1971). A 10% (W/V) homogenate of the midgut tissue was prepared according to the method of Eguchi and Arai (1983).

Both haemolymph and midgut tissue homogenate samples were centrifuged at 3000 rpm for 10 mins to remove haemocytes and tissue residue respectively and stored at -20°C until use.

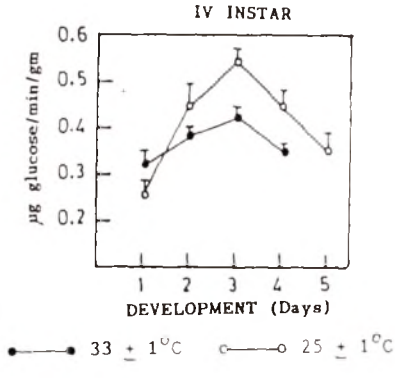
The amylase activity was assayed following the method of Ishaaya and Swirski (1970). The stored samples of haemolymph and midgut after appropriate dilution were used as the enzyme source. The values were expressed as μg glucose liberated/min/ml and μg glucose liberated/min/gm for haemolymph and midgut samples respectively.

RESULTS

In C-nichi strain, both the midgut and haemolymph amylase showed minimum activity during IV instar reared at 33°C compared to larvae reared at 25°C (Figs. 1 and 2) and vice versa during V instar (Figs. 3 and 4). The peak activity of midgut amylase was on 3rd day of both IV and V instars reared at 33°C, whereas in larvae reared at 25°C, the peak was on the 3rd day of IV instar and on the 4th day of V instar (Figs. 1 and 3). The haemolymph amylase showed its peak activity on the 2nd day of IV instar and on the 3rd day of V instar when reared at 33°C (Figs. 2 and 4).

In KA strain, the midgut and haemolymph amylase activity was maximum in the larvae reared at 33°C, during the initial stages of both IV and V instars (Figs. 5 to 8). The larval life was also shorter in the larvae reared at 33°C compared to larvae reared at 25°C. The peak activity of midgut amylase was on the 2nd day of IV and V instars reared at 33°C (Figs. 5 and 7) and on the 3rd day of IV instar and on the 4th day of V instar reared at 33°C. The haemolymph amylase showed its peak activity on the 2nd day of IV instar and on the 3rd day of IV instar at 33°C and on the 3rd day of IV instar on the 4th day of V instar at 25°C (Figs. 6 and 8).

The larval life was shorter in both the races (C-nichi) and (KA) by one day during IV instar and 2 days during V instar stage when reared at 33°C compared to larvae reared at 25°C. The multivoltine (C-nichi) strain showed better amylase activity compared to bivoltine (KA) strain.



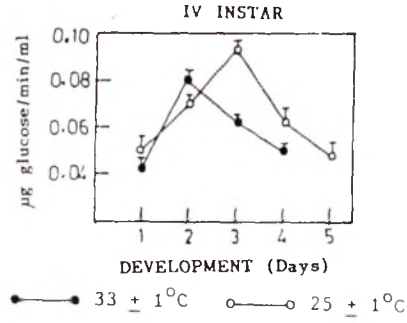
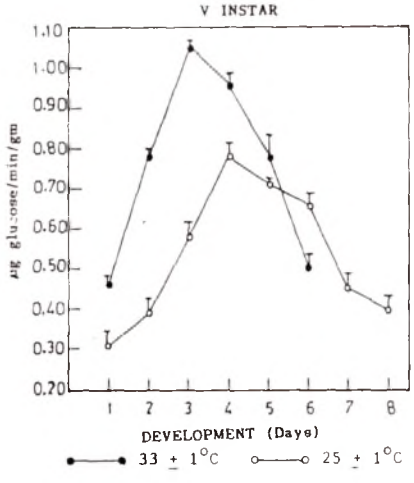


Fig. 2



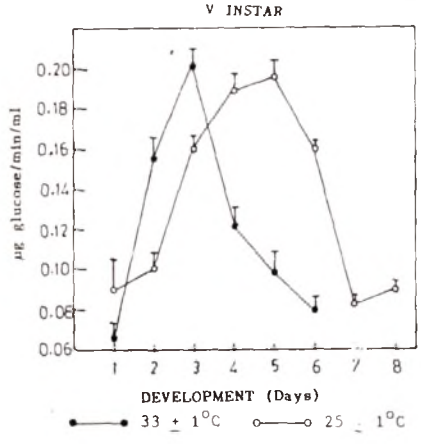
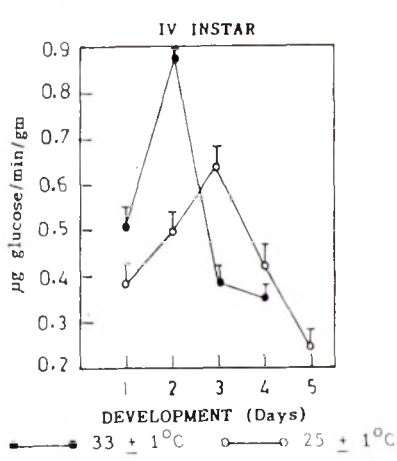


Fig. 3 Fig. 4

Temperature effect on the amylase activity of multivoltine C-nichi strain. Fig. 1. Midgut of IV instar; Fig. 2. Haemolymph of IV instar; Fig. 3. Midgut of V instar; Fig. 4. Haemolymph of V instar.

DISCUSSION

Matsumura and Ishizaka (1929) reported that temperature is harmless to the silkworm growth if it ranges from 20°C to 28°C. Fluctuations are noticed in the larval growth leading to variations in the commercial qualities if the temperature is beyond 30°C and below 20°C. In the present investigation, the results clearly indicate that the temperature of 33°C showed adverse effect in the amylase activity, because the peak activity was in the beginning of each instar and the larval life was reduced. But in the larvae reared at 25°C, the amylase activity was maximum in the middle part of each instar, and this stage is the active feeding stage thus correlating the amylase activity with the food intake. The larvae consume less food before and soon after moult. Sometimes the higher amylase activity in the beginning of instar (1st or 2nd day) may be due to the fact that the larvae feed voraciously soon after moult because of starvation during moulting.



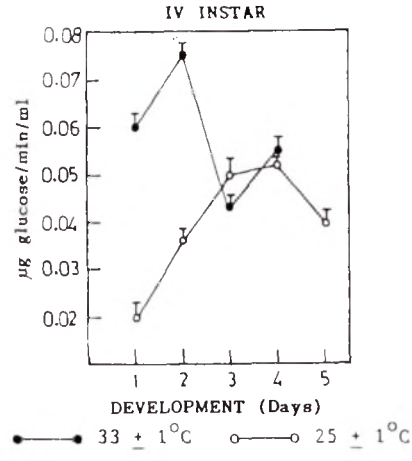
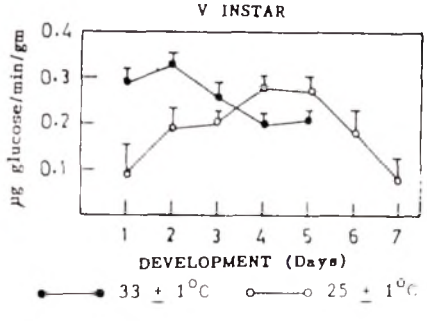


Fig. 5



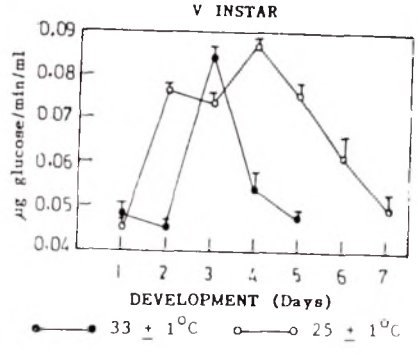


Fig. 7 Fig. 8

Temperature effect on the amylase activity of bivoltine KA strain. Fig. 5. Midgut of IV instar; Fig. 6. Haemolymph of IV instar; Fig. 7. Midgut of V instar Fig. 8. Haemolymph of V instar

The activities of the organism are influenced directly or indirectly by the environment. The extreme conditions of the environment may upset physiological aspects of the insects (Benchamin and Nagaraj, 1987). Nutrition is one of the most important determinants of physiological character.

The enzyme activity of the haemolymph showed a higher value compared to midgut, since the haemolymph is the carrier of the enzymes. The results of the present investigation clearly depicts that even though C-nichi strain is a poor producer of silk under normal conditions compared to bivoltine KA the influence of high temperature showed better activity with regard to amylase in C-nichi strain.

ACKNOWLEDGEMENTS

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Records of Drosophilidae with Description of Two New Species from Bhutan (Insecta: Diptera)

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Abstract: Altogether twenty species representing seven genera of the family Drosophilidae have been recorded for the first time from Bhutan. Details of these species including the taxonomic description of two new species, *Lordiphosa paraflabella* and *Nesiodrosophila neocirricauda* are provided.

Keywords: Drosophilidae, Taxonomy, *Lordiphosa, Nesiodrosophila*

INTRODUCTION

The family Drosophilidae is a large group of flies of world-wide distribution. On world basis the family comprised over 2800 species (Wheeler, 1981, '86). The number of species however, has increased considerably since then due to the description of many more new species from different countries. By and large, the compositions of drosophilid fauna of most of the countries are now fairly established. However, Bhutan, a small country on the eastern Himalayas with China on the north and India on the South, has not attracted the attention of many *Drosophila* workers until recently (De and Gupta, 1995) and whose entire land still awaits exploration.

The present paper represents the results of the first surveying study carried out recently in the vicinity of Phuntsholing, a boarder town of Bhutan.

The flies for the present study were largely collected by net-sweeping over wild vegetation. Occasionally flies were also collected directly with the help of aspirator while they were at rest. For systematic study the procedure of Gupta (1969) was adopted. The type specimens were deposited in the "*Drosophila* collection" of the Department of Zoology, Banaras Hindu University, Varanasi.

DESCRIPTION

Genus *Drosophila* Fallen.

Drosophila Fallen, 1823, Geomyzides Sueciae, 2: 4. Type species: *Musca funebris* Fabricius; Sweden.

Received on March 6, 1995. *Corresponding author

Subgenus Sophophora Sturtevant.

Sophophora Sturtevant, 1939, Proc. Nat. Acad. Sci., 25: 139. Type species: *D. melanogaster* Meigen; Europe.

Drosophila melanogaster Meigen.

D. melanogaster Meigen, 1830, Syst. Beschreib., 6: 85. Specimens examined: 68 ♂, 82 ♀, October, 1993, Phuntsholing, Bhutan.

Distribution: Cosmopolitan, Bhutan (New record).

Drosophila ananassae Doleschall

D. ananassae Doleschall, 1858, Nat. Tijd. Ned. Ind., 17: 128.

Specimens examined: 87 ♂, 113 ♀, October, 1993, Phuntsholing, Bhutan.

Distribution: Cosmopolitan, Bhutan (New record).

Drosophila bipectinata Duda.

D. bipectinata Duda, 1923, Ann. Mus. Nat. Hung., 20: 52.

Specimens examined: 3 ♂, 2 ♀, October, 1993, Phuntsholing, Bhutan.

Distribution: Australia, New Guinea, Cambodia, Celebes, Malaysia, Indonesia, Fiji, Taiwan, Philippines, Thailand, Micronesia, Samoa, Ryukyu Is., Singapore, Japan, Nepal, Pakistan, Sri Lanka, India and Bhutan (New record).

Drosophila malerkotliana Parshad and Paika

D. malerkotliana Parshad and Paika, 1964, Res. Bull., Punjab University, 15: 235.

Specimens examined: 43 ♂, 21 ♀, October, 1993, Phuntsholing, Bhutan.

Distribution: India, Indonesia, Malaysia, Singapore, Thailand, Ivory Coast, Sri Lanka, Celebes and Bhutan (New record).

Drosophila kikkawai Burla

D. kikkawai Burla, 1954, Rev. Brasil. Biol., 14: 47.

Specimens examined: 2 ♂, 8 ♀, October, 1993, phuntsholing, Bhutan.

Distribution: Indonesia, Malaysia, Philippines, Taiwan, Thailand, China, Ryukyu Is., Vietnam, Micronesia, New Guinea, Australia, Samoa, South America, India and Bhutan (New record).

Subgenus Drosophila Fallen S. Str.

Drosophila Fallen, 1823, Geomyzides Sueciae, 2: 4. Type species: *Musca funebris* Fabricius; Sweden.

Drosophila nasuta Lamb

D. nasuta Lamb, 1914, Trans. Linn. Soc., 16: 346.

Specimens examined: 24 ♂, 66 ♀, October, 1993, Phuntsholing, Bhutan.

Distribution: Sri Lanka, Africa, Madagascar, Mauritius, Seychelles, Micronesia, Indonesia, Taiwan, New Guinea, Fiji, Samoa, Hawaii, Nepal, India and Bhutan (New record).

Subgenus Dudaica Strand

Dudaica Strand, 1943, Folia Zool. et. Hydrobiol., 12: 212. Type species: *Drosophila senilis* Duda; Philippines.

Drosophila senilis Duda

D. senilis Duda, 1926, Suppl. Entomol., 14: 91. Syn. *Zygothrica malayana* Takada, 1976, Kontyu, 44: 68.

Specimens examined: 3 ♂, 4 ♀, October, 1993. Phuntsholing, Bhutan.

Distribution: Philippines, Indonesia, India and Bhutan (New record).

Genus Lordiphosa Grimaldi

Lordiphosa Basden, 1961, Beitr. Ent., 11: 186 (as subgenus of the genus *Drosophila*). Type species: *Drosophila fenestrarum* Fallen.

Lordiphosa Grimaldi, 1990, (as a genus) Bull. Amer. Mus. Nat. His., 197: 1-139.

***Lordiphosa paraflabella* sp. nov.**

Average length of body: 2.0-2.1 mm. (♂), 2.1-2.25 mm. (♀).

Head ♂♀: Arista with about 3 dorsal and 2 ventral branches in addition to small terminal bifurcation. Antenna with both pedicel and first flagellomere brown. Frons and fronto-orbital plate glossy black. Facial carina black and prominent. Clypeus black. Vibrissa single, large and stout. Palpus brown, with one strong and two fine apical setae. Gena black and broad, greatest width of gena nearly 2/7 the greatest diameter of eye. Eyes dark red. Anterior reclinate orbital very small; proclinate orbital 2/3 the length of posterior reclinate.

Thorax ♂♀: Scutum and scutellum unicolourous, dark brown. Acrostichal setulae in 6 regular rows. The distance between anterior and posterior dorsocentrals 2/5 the distance between two anterior dorsocentrals. Basal scutellars nearly parallel; apical scutellars convergent. Thoracic pleura dark brown.

Legs ♂♀: Yellowish brown. Apicals on first and second tibiae, preapicals on all three tibiae.

Wings ♂♀: Smoky brown, with two faint large patches. Approximate wing vein indices: C-index 1.45; 4V-index 2.3; 4C-index 1.6; 5X-index 1.8; C_3 fringe 0.6. Halter pale.

Abdomen ♂♀: Tergites uniformly dark brown to black.

Male terminalia (Fig. 1): Epandrium dark brown, large and broadly rounded below, setigerous, upper portion with 2-3 setae and lower with 11-12 setae. Cercus elongate, separate from epandrium, setigerous, with two very large thick setae in middle and 14-15 moderate setae around. Surstylus brown, triangular, with 9 small black prensisetae and about 14 small yellow setae on its inner surface an outer margin. A tubular process emerging from epandrium between cercus and surstylus, with about 8 large distal setae.

Aedeagus straight, long, apically narrowing. Apodeme much longer than aedeagus. Parameeres small, with three fine sensilla. Gonopods fused together forming a lobe with flap-like structure laterally. Hypandrium without submedian spines. Hypandrial apodeme much longer than broad, round distally (Fig. 2).

Holotype ♀, Bhutan Phuntsholing, October, 1993 (De and Gupta).

Paratypes: 2 ♂♂, 2 ♀♀, same locality and collectors as holotype. Deposited in the "*Drosophila* Collection", Department of Zoology, Banaras Hindu University, Varanasi, India.

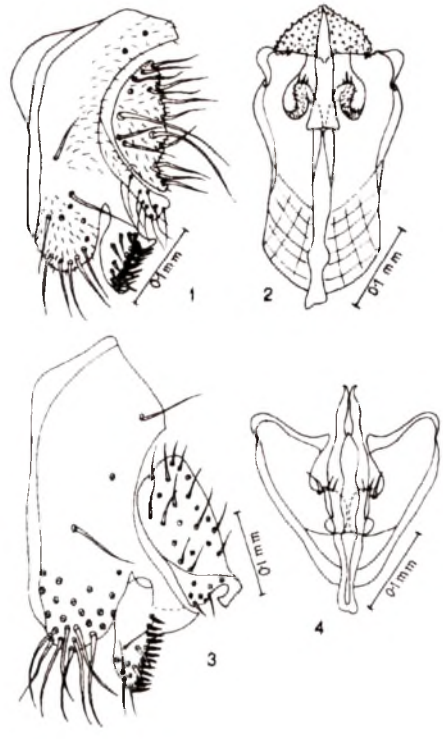
Relationships: This species closely resembles *L. serriflabella* Okada (1966) in having fused posterior parameres of male terminalia, but differs clearly from it in having much darker body colouration (yellowish brown in *serriflabella*); C-index 1.45 (2.4 in *serriflabella*); two halves of epandrium jointed below cercus (epandrum not jointed below cercus in *serriflabella*) and aedeagus straight, long, apically narrowing (aedeagus setulose in *serriflabella*).

Key to species of the genus *Lordiphosa* found in India and Bhutan:

1 Posterior margin of epandrium extended like a tubular process between cercus and surstylus ..... *paraflabella* sp. nov.
- Posterior margin of epandrium not extended like a tubular process between cercus and surstylus 2
2 Scutum with two broad, dark brown lateral stripes .... *himalayana* Gupta and Gupta
- Scutum without dark lateral stripes 3
3 Epandrium forming tubular process ventrally 4
- Epandrium not forming tubular process ventrally 5
4 Paramere branched apically ..... *peniglobosa* Kumar and Gupta
- Paramere truncate apically ..... *aurantifrons* Okada
5 Thoracic pleura with 3 black stripes ..... *acutissima* Okada
- Thoracic pleura without stripes 6
6 Surstylus with 2 sets of prensisetae ..... *neokurokawai* Singh and Gupta
- Surstylus with 1 set of prensisetae 7
7 Paramere distally narrowing and setulose ..... *coei* Okada
- Paramere distally not narrowing and setulose . *parantillaria* Kumar and Gupta

Note: *L. paraflabella* is the only species of the genus *Lordiphosa* recorded from Bhutan so far.

Genus *Nesiodrosophila* Wheeler and Takada ..... *Nesiodrosophila* Wheeler and Takada, 1964, Insects of Micronesia, 14 (6): 163-242. Type species: *Nesiodrosophila lindae* Wheeler and Takada; Caroline Is.



Figs. 1-4. *Lordiphosa paraflabella* sp. nov.: 1. Epandrium, cercus and surstylus; 2. Aedeagus, hypandrium and paramere; *Nesiodrosophila neocirricauda* sp. nov.: 3. Epandrium, cercus and surstylus; 4. Aedeagus, hypandrium and paramere.

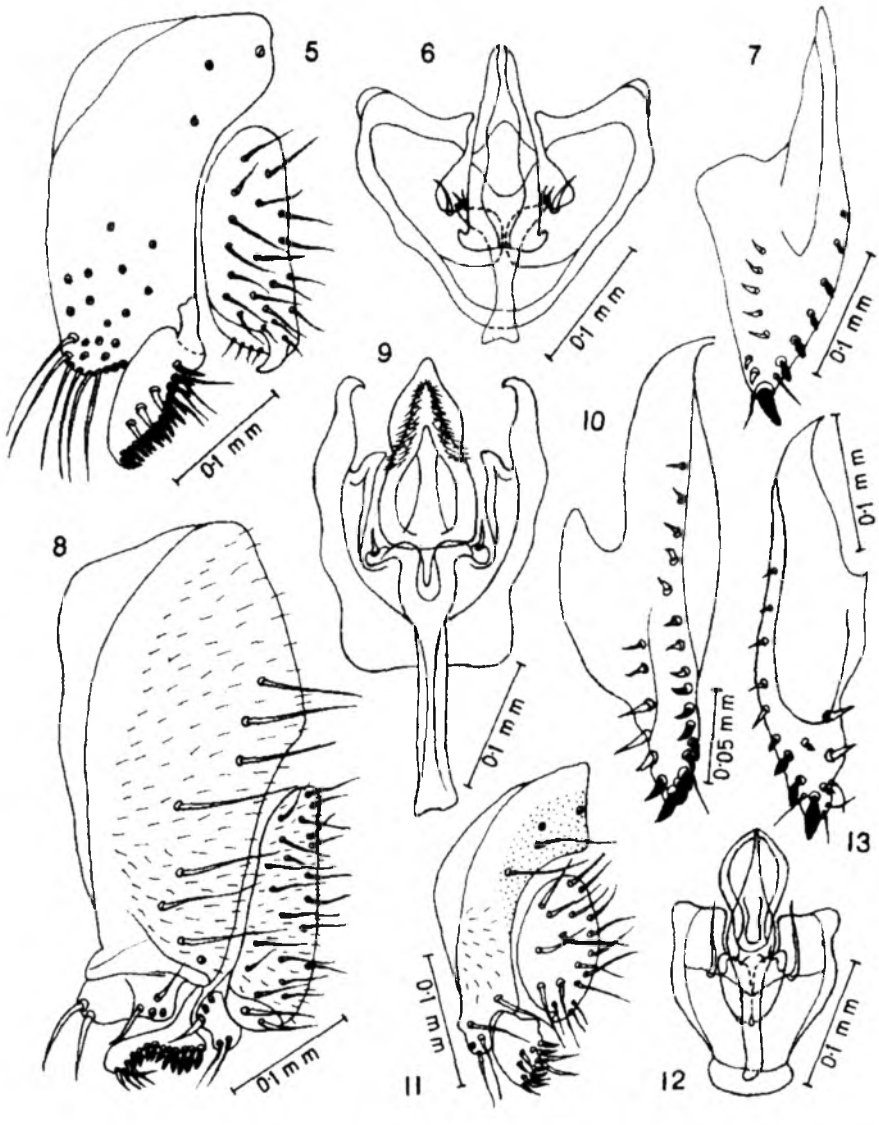
Nesiodrosophila neocirricauda sp. nov.

Average length of body: 1.8-1.9 mm (♂); 1.95 (♀).

Head ♂♀: Arista with 5-6 dorsal and 2 ventral branches in addition to terminal bifurcation. Antenna with pedicel light brown, first flagellomere darker. Frons and fronto-orbital plate brown. Facial carina short and low. Clypeus brown. Vibrissa large and strong, second oral fine. Face flat. Palpus brown, with one large apical seta. Gena brown, greatest width of gena 1/7 the greatest diameter of eye. Eyes dark red. Anterior reclinate orbital smaller than other orbitals. Proclinate orbital 5/7 the length of posterior reclinate.

Thorax ♂♀: Scutum pale brown, basally much darker; scutellum dark brown. Acrostichal setulae in 6 regular rows. The distance between anterior and posterior dorsocentrals 5/9 the distance between two anterior dorsocentrals. Basal scutellars nearly parallel; apical scutellars convergent. Thoracic pleura dark brown.

Legs ♂♀: Pale brown. Apical seta on first and second tibiae, preapicals on all three tibiae.



Figs. 5-13. *Nesiodrosophila cirricauda*: 5. Epandrium, cercus and surstylus; 6. Aedeagus, hypandrium and paramere; 7. Oviscapt. *Liodrosophila trichaetopennis*. 8. Epandrium, cercus and surstylus; 9. Aedeagus, hypandrium and paramere; 10. Oviscapt. *Liodrosophila fasciata*: 11. Epandrium, cercus and surstylus; 12. Aedeagus, hypandrium and paramere; 13. Oviscapt.

Wings ♂♀: Hyaline. Approximate wing vein indices: C-index 1.4; 4V-index 2.7; 4C-index 1.9; 5x-index 2.5; C_3 fringe 0.85. Halter white.

Abdomen ♂♀: Tergites uniformly dark brown.

Male terminalia: Epandrium yellowish brown, large, broadly projected below, with 3 upper and about 25 large setae ventrally. Surstylus elongate with 12 black prensisetae and 7-8 large setae on inner surface. Cercus rectangular with a blunt, small projection at outer lower margin and with about 30 setae (Fig. 3).

Aedeagus robust, conical. Apodeme about half the length of aedeagus. Parameres small, with two apical sensilla. Hypandrium with a pair of submedian spines. Hypandiral apodeme triangular (Fig. 4).

Holotype ♀, Bhutan, Phuntsholing, October, 1993 (De and Gupta). Paratypes: 13 ♂♂, 6♀♀, same locality and collectors as holotype. Deposited in the "*Drosophila* Collection", Department of Zoology, Banaras Hindu University, Varanasi, India.

Relationships: This species closely resembles *Nesiodrosophila cirricauda* Okada (1988) in general morphology and the structure of male terminalia, but differs clearly from it in having overall paler body colouration (body mostly blackish brown to black in colour in *cirricauda*); Arista branches 6-7/2 (5/1 in *cirricauda*); and cercus with a blunt process ventrally (pointed triangular ventral process in *cirricauda*).

Nesiodrosophila cirricauda Okada

N. cirricauda Okada, 1988, Ent. Scand. Suppl., 30: 109-149.

Specimens examined: 8 ♂♂, 17 ♀♀, October, 1993, Phuntsholing, Bhutan.

Distribution: Sri Lanka, Bhutan (New record).

Remarks: This species has not been recorded so far from India. Details of its male and female terminalia are shown in figures 5-7.

Key to species of the genus *Nesiodrosophila* found in India and Bhutan:

1 Thoracic pleura with 2 dark longitudinal stripes
lindae Wheeler and Takada

- Thoracic pleura without longitudinal stripes 2

2 Arista branches 5-6/2'; cercus with a ventral blunt process
neocirricauda sp. nov.

- Arista branches 5/1; cercus with a ventral pointed process
cirricauda Okada

Note: *N. lindae* is only recorded from India and the other two species from Bhutan only.

Genus Liodrosophila Duda

Liodrosophila Duda, 1922, Arch. Naturgesch A, 88(4): 153. Type species: *Camilla coeruleifrons* de Meijere; Indonesia.

Liodrosophila trichaetopennis Takada and Momma

L.trichaetopennis Takada and Momma, 1975, J. Fac. Sci., Hokkaido University, 20(1): 9-48.

Specimens examined: 200 ♂♂, 187 ♀♀, October, 1993, Phuntsholing, Bhutan.

Distribution: Malaysia, Bhutan (New record).

Remarks: This species has not been recorded so far from India. Details of its male and female terminalia are shown in figures 8-10.

Liodrosophila fasciata Duda *L. fasciata* Duda, 1926, Suppl. Ent., 14: 54.

Specimens examined: 43 ♂♂, 42 ♀♀, October, 1993, Phuntsholing, Bhutan.

Distribution: Indonesia, Malaysia and Bhutan (New record).

Remarks: This species has not been recorded so far from India. Details of its male and female terminalia are shown in Figures 11-13.

Liodrosophila ceylonica Okada *L. ceylonica* Okada, 1974, Mushi, 48(5): 29-63.

Specimens examined: 11 ♂♂8 ♀♀, October, 1993, Phuntsholing, Bhutan.

Distribution: Sri Lanka, Taiwan, India and Bhutan (New record).

Key to species of the genus *Liodrosophila* found in India and Bhutan:

1 Wing with four large black patches ..... *quadrimaculata* Okada
- Wing without black patches 2
2 Abdomen yellow with medianly interrupted caudal black bands *fasciata* Duda
- Abdomen dark without medianly interrupted caudal black bands 3
3 Acrostichal setulae in two rows 4
- Acrostichal setulae in 4-6 rows 5
4 Aedeagus fusiform and hairy ..... *ceylonica* Okada
- Aedeagus oblong and distally pubescent ..... *globosa* Okada
5 Thoracic pleura orange brown ..... *penispinosa* Dwivedi and Gupta
- Thoracic pleura dark brown to black 6
6 C-index less than 1.0 ..... *nana* Wheeler and Takada
- C-index more than 1.0 7
7 Fore femur with a row of about 8-9 spinules ..... *rufa* Okada
- Fore femur with a row of about 13-21 spinules 8
8 Spinules on fore femur with fine basal setulae *minidenta* Gupta and Gupta
- Spinules on fore femur without fine basal setulae 9
9 Body brown; aedeagus with flap-like structure basally *angulata* Dwivedi *et al.*
- Body jet black; aedeagus without flap-like structure basally 10
10 Cercus with some lobular structures basally; aedeagus setulose *trichaetopennis* Takada and Momma
- Cercus without lobular structures; aedeagus not setulose *Okadai* Dwivedi and Gupta

Genus Hypselothyrea de Meijere

Hypselothyrea de Meijere, 1906, Annls. Mus. Nat. Hung., 4: 193. type Species: *Hypselothyrea dimidiata* de Meijere, New Guinea.

Hypselothyrea guttata Duda

H. guttata Duda, 1926, Suppl. Ent., 14: 56.

Specimens examined: 1♂, 1♀, October, 1993, Phuntsholing, Bhutan.

Distribution: Indonesia, Nepal, Taiwan, India and Bhutan (New record).

Genus Microdrosophila Malloch

Microdrosophila Malloch, 1921, Ent. News, 32: 12. Type species: *Drosophila quadrata* Sturtevant; USA.

Subgenus Oxystyloptera Duda

Oxystyloptera Duda, 1924, Arch. Naturgesch., 90 A_3: 192.

Microdrosophila paradistincta De and Gupta

M. paradistincta De and Gupta, 1994, Senckenbergiana biol., 74(1/2): 153-156.

Specimens examined: 8 ♂♂, 5 ♀♀, October, 1993, Phutsholing, Bhutan.

Distribution: India and Bhutan (New record).

Genus Mulgravea Bock

Mulgravea Bock, 1982, Austr. J. Zool., Suppl. 89: 122. Type species: *Mulgravea minima* Bock; Queensland.

Thyreocephala Okada, 1985, Kontyu, 53: 338. Type species: *Lissocephala asiatica* Okada; Amami IS.

Mulgravea ranipoolensis Kumar and Gupta

M. ranipoolensis Kumar and Gupta, 1991, Senckenbergiana Biol., 72(1/3): 45-51.

Specimens examined: 4♂♂, 4♀♀, October, 1993, Phuntsholing, Bhutan.

Distribution: India and Bhutan (New record).

Mulgravea detriculata De and Gupta

M. detriculata De and Gupta, 1995, Oriental Insects 29: 359-369.

Specimens examined: 9 ♂♂, 18♀♀, October, 1993, Phuntsholing, Bhutan.

Distribution: Bhutan.

Mulgravea bhutanica De and Gupta

M. bhutanica De and Gupta, 1995, Oriental Insects, 29: 359-369.

Specimens examined: 5♂♂, October, 1993, Phuntsholing, Bhutan.

Distribution: Bhutan.

Mulgravea peniglobosa De and Gupta

M. peniglobosa De and Gupta, 1995, Oriental Insects, 29: 359-369.

Specimens examined: 14 ♂♂, 10 ♀♀, October, 1993, Phuntsholing, Bhutan.

Distribution: Bhutan.

Mulgravea spinisterna De and Gupta

M. spinisterna De and Gupta, 1995, Oriental Insects, 29: 359-369.

Specimens examined: 2 ♂♂, October, 1993, Phuntsholing, Bhutan.

Distribution: Bhutan.

Acknowledgement

This work was supported by a research grant of University Grants Commission, New Delhi to JPG.

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Entomon 21 (2): 187–189 (1996)

Short Communication

Effect of application of insecticides at varying intervals on control of the coreid bug *Paradasynus rostratus* Dist. on coconut

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Abstract: For control of coreid bug in very heavily infested coconut gardens, Carbaryl 0.1% spray four times an year (avoiding the rainy season) can be recommended.

Keywords: Coreid bug, control using insecticides.

The coreid bud *Paradasynus rostratus* Dist. has become a notorious pest of coconut (*Cocos nucifera*) in Kerala in recent years. The adults and nymphs desap the buttons and cause heavy shedding. The nuts which escape shedding remain on the palms showing severe gummosis characteristics, crinkling and malformation. (Kurian *et al.* 1972, 1976 and Ponnamma *et al.* 1985). Carbaryl, HCH and endosulfan have been found effective for the control of the pest (Visalakshi *et al.* 1987). However the optimum frequency of treatment has not been fixed. Hence a trial was conducted during 1985 to 1987 at Chirayinkil, Trivandrum district with the above objectives under NARP (SR).

The experiment was laid out in Randomized Block Design and the insecticides evaluated were HCH suspension and dust and carbaryl suspension (Table 1). The insecticides were applied once a month (8 times per year) avoiding the heavy monsoon, once in two months (6 times per year) and once in three months (4 times per year). Each treatment was replicated six times and each replication comprised five palms. The insecticide suspensions were sprayed with a rocker sprayer using 1.5 litres of spray fluid per palm and HCH 10% dust at 100 g/palm. The buttons shed from each palm were collected daily and the number infested by the bug counted, observing the lesions produced on the perianth. The percentage of buttons damaged was worked out of the total observed every month. The total number of nuts on the mature bunch of every palm and the number of nuts showing damage by the bug were also recorded. Then the percentage of malformed nuts was worked out. The income per palm as a result of insecticide application over control was studied in 20 bunches harvested from each palm during the course of the study. This was worked out by

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Table 1: Effect of insecticides applied at different intervals on the control of coreid bug infestation on coconut

Treatments/ Insecticide	Percentage of buttons infested by coried bug	Percentage of mature nuts infested by coreid bug	Income per palm over control during experimental period (yield of 20 bunches were studied)	B:C ratio
HCH 0.2% spray 8 times/year	5.83 (13.96)	13.34 (21.35)	206.00	11.77:1
HCH 0.2% spray 4 times/year	14.27 (22.12)	26.58 (30.94)	110.00	8.40:1
HCH 0.2% spray 4 times/year	16.99 (28.39)	29.98 (33.12)	130.00	15.95:1
Carbaryl 0.1% spray 8 times/year	10.63 (18.94)	14.44 (22.26)	131.00	6.56:1
Carbaryl 0.1% spray 6 times/year	22.02 (27.93)	25.24 (30.10)	70.00	4.61:1
Carbaryl 0.1% spray 4 times/year	29.27	34.68	120.00	12.0:1
HCH 10% dust 100g palm 8 times/year	7.64 (16.01)	11.14 (19.44)	118.00	5.90:1 5.90:1
HCH 10% dust 100g palm 6 times/year	18.15 (25.19)	19.03 (25.49)	99.00	6.60:1
HCH 10% dust 100g palm 4 times/year	24.66 (29.75)	32.33 (34.41)	93.00	9.30:1
Control	38.67 (38.41)	48.26 (43.99)		
CD. at 5% level	(2.19)	(5.44)		

Figures given in parenthesis are transformed values

fixing the price of healthy and damaged nuts based on the prevailing market price at each harvest.

The results presented in the table showed that the least percentage of bug damage on buttons was in palms treated with HCH 0.2% spray eight times per year, but it was on par with HCH applied as dust eight times a year. All the treatments were superior to control, where the maximum percentage of infestation (38.67%) was observed. The lowest percentage of infested mature nuts was observed in the palms treated with HCH 10% dust eight times an year, but it was on par with HCH 0.2% and carbaryl 0.1% suspensions applied eight times an year. All the treatments were superior to control where the highest damage of 48.26% was noticed on nuts. The highest income of Rs. 206 per palm was realised from palms receiving eight sprays

of HCH 0.2% a year. Among the other treatments, the income ranged from Rs. 70 to Rs. 131 per palm over control. The benefit: cost ratio of the treatments were worked out. The highest benefit cost ratio of 5.95:1 was obtained in HCH 0.2% spray four times a year followed by carbaryl 0.1% spray four times a year. However due to the persistence of HCH in the ecosystem, carbaryl can be used.

Thus for control of the coreid bug in heavily infested coconut palms, carbaryl 0.1% spray four times a year (avoiding the rainy season) can be recommended.

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Entomon 21 (2): 191–193 (1996)

Short Communication

A New Mole Cricket of the Genus *Scapteriscus* (Orthoptera: Gryllotalpidae) from Arunachal Pradesh, India

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Abstract: A new species of the American genus *Scapteriscus* has been described from Lohit district, Arunachal Pradesh, India. A key has been provided accommodating the new species.

Keywords: *Scapteriscus*, mole cricket, new species

The mole cricket *Scapteriscus* is one of the most characteristic genus of the American fauna, nearly eleven species of this genus are known from the American continent. Chopard (1928) reported the genus for the first time from Indian region and described *Scapteriscus leptodactylus* a new species from Dhakuria, Bangladesh. Tandon and Shishodia (1972) published a new species *Scapteriscus siangensis* from West Siang district of Arunachal Pradesh. In the present account the author encountered 3 specimens of *Scapteriscus* which on careful examination have turned out to be a new species.

The intervening tract in the distribution of *Scapteriscus* viz. American continent, India and Bangladesh, there is vast gap where no representative of the genus occurs showing discontinuous distribution. It must however be mentioned that there is one possibility to explain the discontinuity. The mole crickets usually present rather wide distribution, they may be easily transported with plants.

DESCRIPTION

Female size rather large and stout. Head covered with small hairs, dark brown, conical, narrow with two small lateral ocelli situated apart (about 4 times the size of ocellus) Antennae filiform, pubescent. Eyes black, antennae brown and slender. Pronotum convex narrowing anteriorly; anterior margin concave; dorsal shield brown with a longitudinal pattern on the median part of the disk; lateral lobes bent towards the median line beneath.

Legs:

The anterior legs are distinguished and adapted for fossorial habits. Their characteristic conformation; the coxa is stout and short; the femur is like a thick, curved plate;

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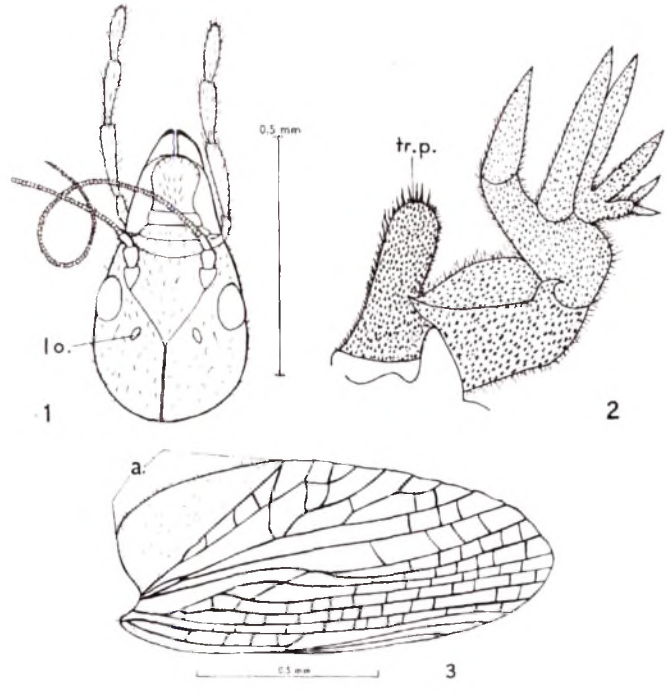

Fig. *Scapteriscus indicus* Sp. nov. 1. Head dorsal view, lo, lateral ocellus, an. antenna, e. eye, cl. clypeus, lb. labrum. 2. Anterior leg dorsal view, tr. p. trochanter process, tb. tibia. 3. Left elytron to show pubescence on the a. anal region. p. v. parallel veins.

the tibia is triangular, very short and armed with two strong cutting dactyls which are long and wide apart; tarsi claws long and narrow. The process of trochanter of anterior leg long and narrow covered with short hairs on the body and long bristles all along its inferior margin. Anterior tibiae with completely uncovered tympanum. The tibia and tarsi are covered with peg like structures. Posterior tarsi with the third joint very strongly enlarged, compressed with subequal claws.

Tegmina transluscent, glabrous (except the anal region) light brown in colour, extending up to the third abdominal tergite. Elytral venation is plain, formed of rather regular veins, separated by veinlets which form small aerolae; anal field devoid of veins and provided with an abundant pubescence. Wings long almost equal to the body size. The ovipositor is completely aborted.

Measurements (in mm.):

Length of body	25.5
Length of pronotum	9
Length of elytra	10.5
Length of wings	25
Length of ocellus	0.35

Width of ocellus	0.21
Distance between the ocelli	0.93

Holotype:

One female (ii) Paratypes two females (in spirit)

Type locality:

Kamlang, Lohit distt., Arunachal Pradesh, 21.x.1886. Coll. R.N. Bhargava

The species of *Scapteriscus* known to occur in the Indian region including the present one can be keyed as follows.

1.	Ocelli separated by a space scarcely equal to their own length	*leptodactylus* Chopard
	Ocelli separated by a space more than their own length	2
2.	Ocelli separated by a space almost double their length	*siangensis* Tandon and Shishodia
3.	Ocelli separated by space nearly four times their length	*indicus* sp. novo.

REMARKS

The new species shows resemblance in general aspects with *Scapteriscus siangensis* Tandon and Shishodia (1972) but it differs in the extension of tegmina reaching up to the apex of 3rd abdominal tergite, in the space between the two ocelli nearly four times their length.

Acknowledgements

I am indebted to the Director, Zoological Survey of India, Calcutta for encouragements and to Dr. Q. H. Baqri, Officer-in-Charge, Desert Regional Station, Zoological Survey of India, Jodhpur for facilities. I am obliged to Dr. R. C. Sharma, Emeritus Scientist and Dr. N. S. Rathore of this Station for constructive criticism and technical help.

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Entomon 21 (2): 195–197 (1996)

Short Communication

Description of a New Species of Mite of the Genus *Typhlodromus* (Acarina: Phytoseiidae) from Eastern India

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Abstract: The paper describes a new species of genus *Typhloctonus* Scheuten, 1857, from eastern India on egg plant

Keywords: New species, Phytoseiidae mite, *Typhloctonus*, India

The phytoseiidae mites are of considerable economic importance because of their predatory habit on other phytophagous mites. The mites of the genus *Typhloctonus* are of great economic importance as they are efficient predator of tetranychid mites. Genus *Typhloctonus* is described from Indian subcontinent which includes 79 species. The reported species is no way related to any of the 79 species of genus *Typhloctonus*. However, the species *T. (T.) aceri* is reported from England which was observed to be closely related with this new species from eastern India, Uttar Pradesh. So far 32 species reported from India, 33 from Pakistan, 1 from Nepal, 3 from Bhutan, 1 from Burma, 3 from Philippines, 2 each from Taiwan, Thailand and South China. But none from Bangladesh and Sri Lanka (as per Gupta, 1987). A new species of *Typhloctonus* collected from egg plant is here in described with necessary sketches. The types are deposited in the AICRP Agricultural Acarology, Department of Entomology and Agril. Zoology, Banaras Hindu University, Varanasi. All measurements given in the text are in micrometer (μm). Chant (1959, 1965) is followed for setal nomenclature.

***Typhloctonus (Typhloctonus) malviyai* sp. nov. (Fig. 1)**

Females:

Dorsal shield 434 long and 223.2 wide, smooth with 19 pairs of setae, 11 pairs in the lateral rows, Setae Z_4 and Z_5 serrate. Measurements of setae: j_1-10.4, j_4-12.4, j_5-33.8 j_6-14.3, j_2-6.5, $j_3$9.1, j_3-39, z_2-20.1, z_3-20, z_4-27.3, s_4-32.5, s_6-35.1, z_1-26 s_2-27.3, s_4-35.1, s_5 13.6 z_5-36.4, z_5-20 z_4-19.5. Sternal shield with 2 pairs of sternal setae. Metasternal plates with a pair of metasternal setae. Genital shield with a pair of setae. Ventrianal shield longer 151 than broad 68, with 4 pairs of preanal setae and 4 pairs of setae present on the membrane around. Two pairs of metapodal

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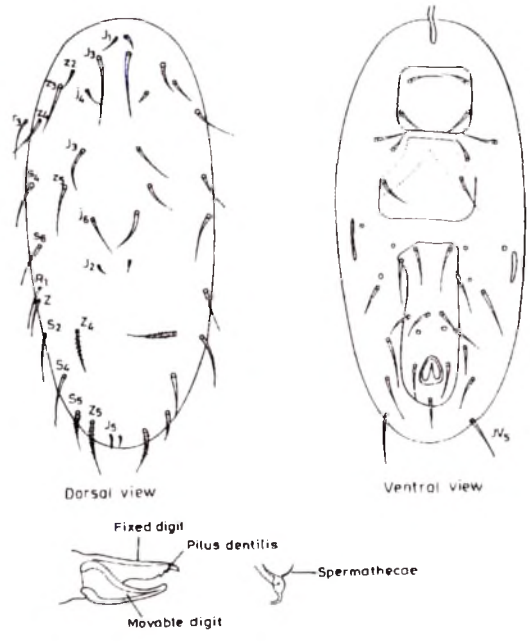

Fig 1. Typhlodromus (Typhloctonus) malviyai sp. nov.

plates. Two pairs of minute sclerotized platelets present in the area around ventrianal shield. Spermatheca with cervix cup-shaped, atrium enlarged 2 μm long. Fixed digit of chelicera bidentate; according to Collyer (1957) and Denmark and Rather (1984), pilus dentilis present; movable digit edentate, 20 μm long. Chaetotactic formula of genu II: 2-2/0, 2/0-1. Measurements of legs and palp as follows: leg I 215; leg II 186; leg III 186; leg IV 234; palp 112. All legs shorter than dorsal shield, without macrosetae.

Male

Unknown

Holotype one female India. Uttar Pradesh

Type of Locality and Distribution

Varanasi, Village-Nuvav, four kilometer, South-East of Banaras Hindu University, Date Feb. 10, 1986 on egg plant (*Solanum melongena*), coll: R. N. Singh

REMARKS

The new species belongs to genus *Typhloctonus* because of having 11 pairs of setae and is close of *T.(T.)aceri* Collyer (1957) in having narrow ventrianal shield, but differs in having elongate metapodal plate instead of round one as in aceri

This species was found predating on tetranychid mites.

Acknowledgements

The authors are thankful to Dr. S. K. Gupta Joint Director, ZSI Calcutta for the determination of the mite as new species and his valuable advise.

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Short Communication

A New Species of Sheath Mite *Ogmotarsonemus oryzae* Sp. Nov. (Tarsonemidae: Acari) on Rice From Tamil Nadu, India

M. Mohanasundaram*

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Abstract: A new species of sheath mite *Ogmotarsonemus oryzae* sp. nov. discovered from the rice leaf sheath causing necrotic lesions has been described with figures.

Keywords: *Ogmotarsonemus*, Tarsonemidae, Rice

In the course of examination for white backed plant hopper (WBPH) eggs in the leaf sheaths of rice plants, several necrotic lesions were often encountered. A closer examination under a stereobinocular microscope around a magnification of 40 x, these lesions were found to harbour a number of tarsonemid mites, females, males and nymphs. No other organism was found in these lesions and observations on a large number of lesions clearly indicated the causative organism as the tarsonemid mites. These mites were recovered, processed and mounted for study, which revealed it to belong to the genus *Ogmotarsonemus* Lindquist (1986) and new to science. This is the second species described under the genus *Ogmotarsonemus*. The descriptions of the female and male are given with adequate illustrations. The type and paratype slides are deposited in the Acarology collections of the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 003, India. All measurements given are in microns. The terminology used in the chaetotaxy is as per Lindquist (1986).

Ogmotarsonemus oryzae sp. nov. (Figs. 1-18)

Adult Female:

260-280 long, 80 wide, dirty white, slow moving in the plant lesions.

Gnathosoma capsule longer than wide, ovoid, 30 long, 24 wide. Palpcoxal seta 2 long, present laterally. Dorsal gnathosomal setae simple, very thin, 12 long; palpi directed anteriorly, slightly convergent; each with two short setae at its tip; cheliceral styles 8 long, curved basally.

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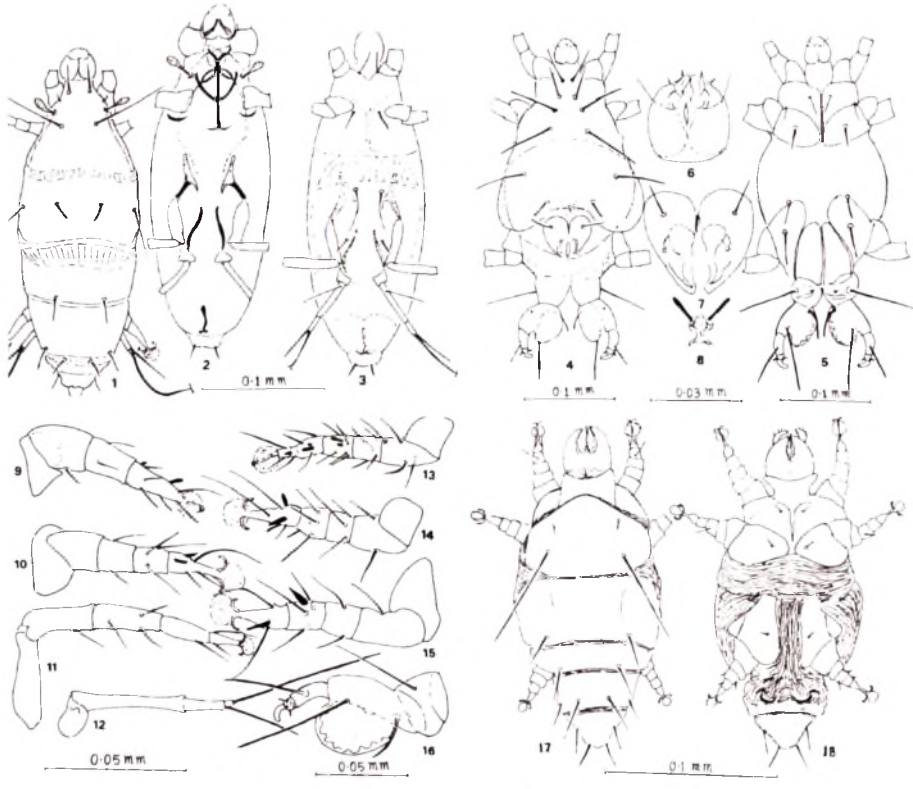

Figures 1-16- *Ogmotarsonemus oryzae* sp. nov. 1. Dorsal view of adult female. 2. Middle view of adult female showing the different apodemes. 3. Ventral view of the female. 4. Dorsal view of adult male. 5. Ventral view of adult male. 6. Dorsal view of gnathosoma. 7. Ventral view of the gnathosoma. 8. Internal apodeme of male. 9 to 12. Legs I to IV of adult female. 13 to 16. Legs I to IV of adult male. 17. Dorsal view of larva. 18. Ventral view of larva.

Idiosoma: Idiosoma elongate, elliptical, dorsal shield smooth; V_1 20 long; SC_2 44 long; C_1 10 long, C_2 20 long, 10 long, all dorsal setae are simple. Pseudostigmatic organ elongate, 20 long. Tergite EF with setae e and f nearly in line crosswise.

Ventral shielding with apodemes 1 farming Y shaped juncture with prosternal apodeme. Apodeme 3 and 4 as shown in figure; all coxal setae present. Agenital plate lacking setae; pseudanal setae present.

Adult male: 220 long; wide, light straw coloured; actively moving in the plant lesions.

Gnathosoma: Ovoid 30 long; 24 wide; dorsal setae very thin; 10 long.

Prodorsum with 4 pairs of setae, all simple; plate CD with two pairs of setae. Apodeme and legs IV are characteristic and as shown in figures.

Larva: Idiosoma capable of normal distension; dorsal shields smooth. Prodorsum with seta $V_1$6 long and very thin; Sc_2 54 long; tergites c, d/ EF entire; all dorsal

setae smooth; coxisternal plates I and II fully fused medially; coxisternal plates III widely separated with characteristic wrinkles in between and surrounding them.

Legs: Ambulacrum of leg I of adult male and female with single weakly formed claw. Ambulacra of legs II and III with empodium and well developed symmetrically paired claws; leg IV of adult female elongate cylindrical with femerogenu about three times as long as tibiotarsus, enidng in a paid of long setae; leg IV of male with a prominent rounded flange between setae Fe-V' and Ge-V' on posterolateral surface; this flange appearing broadly lobe like due to its distal margin forming an acute angle where attached to formerogenu; setation on legs as shown in figures. Larva with segmentation and ambulacra of legs fully developed.

Types: A holotype ♂, allotype ♀and 4 paratype ♂, ♀nymphs marked on slide, India: Tamil Nadu: Coimbatore, 5. IX 1990 ex *Oryza sativa* Linn. (Poaceae), M. Mohanasundram Coll.

REMARKS

This is the second species in the genus *Ogmotarsonemus* Lindquist (1986) and the first record of this genus outside United states. The first species under this genus *O. erepsis* Lindquist (1986) has been found associated with necrotic spots on saltmarsh grass *Spartina* sp. Here the present species was found associated with the necrotic lesions on the leaf sheath of rice plants and all the stages of the mite were encountered, proving it to be phytophagous and the lesions caused due to their feeding. The present new species differs from *O. erepsis* Lindquist by the absence of cuticular pattern on the dorsum; size of the various setae; and the hind legs of the male.

References

Lindquist, E. E. 1986. The world genera of Tarsonemidae (Acari: Heterostigmata): A morphological, phylogenetic and systematic revision, with a reclassification of family-group taxa in the heterostigmata. Mem. Ent. Soc. Canada N. **136**, 285-288.

Entomon 21 (2): 203–204 (1996)

Book Review

Forest Litter Insect Communities: Biology and Chemical Ecology, T. N. Ananthakrishnan, Oxford and IBH Publishing Co. Private Ltd., New Delhi 110001. pp. x+174., Price Rs. 350/-.

The Book "Forest litter Insect Communities: Biology and Chemical Ecology", edited by Prof. T. N. Ananthakrishnan, has eleven chapters giving valuable information regarding litter ecosystem in tropical forests with special reference to arthropod communities, their biology and functional diversity. In the First chapter, the dynamics of litter and the role of litter in forest ecology is explained, giving evidences of pattern of litter fall and phenology of litter production. Dynamics of litter decomposition which leads to faunal interaction is the theme of the 2nd chapter. The microbes are pioneers in decomposition followed by micro-arthropods, mostly insects, mites, symphylids and pauropods. Earthworms and large saprophagous insects increase the rapidity of the break down.

Nutrient cycling patterns in tropical forest litter is discussed in chapter 3, giving importance to the essential nutrients and minerals, highlighting energy stores in live and dead organic matter in natural and manmade forests. The role of soil organisms in the process of humification is also considered. Microbial–microarthropod interaction in litter is the essence of chapter 4, where an extensive account of litter catabolism is dealt with. Microarthropods control the distribution and abundance of litter fungi and bacteria. Details of fungal species in association with L, F and H layers of natural forest litter at Munnar, Idukki forests and Shola forest in Kodaikanal hills; diversity in mite fauna in natural and monoculture forest litter and association of sporophagous thrips with plant pathogenic spores in forest communities are worth mentioning.

A biological assessment of the diverse litter Arthropods in chapter 5 is adding to the wealth of information in the present publication. The Consideration of micropredator communities in the surface layer of litter in chapter 6 is an inseparable part of forest litter ecosystem. The author assures that predator is not a population limiter and that prey-predator system is oscillatory. Detailed record of macropredators given associated with this chapter deserves special attention. In chapter 7, 8 and 9, the author reports detailed account of Resource utilization, touching the chemical ecology, faunal turnover along altitudinal gradients in tropical forests, and trophic system in forest litter communities delineating the interaction of organisms in the food web. In chapter 10, the author does not disregard chances of forest denudation and guild structure which indeed a part of the litter ecosystem.

The eleventh chapter seems to be the most important one, from the practical point of view. The author is considerate to the younger generation of ecologists who are interested in the methods of analysis to study chemical ecology of litter. This chapter

is followed by bibliography and index. In the present book, author has assorted index in to three viz. plant index, animal index and index of general terms. On the whole the book is a valuable contribution to advanced studies in Environmental Science.

Mariamma Jacob

Announcement

ISTCRAD – International Society for Tropical Crop Research and Development, announces Symposium on "*Tropical Crop Research and Development, India–International*", during 9–12 September 1997. Critical analysis on research/developmental activities in all the tropical crops are included in different sessions. Concurrent sessions are arranged for all the disciplines including basic and applied research in agriculture and allied subjects. The schedules fixed are: Receipt of abstracts – 31 March 1997; Intimation on acceptance of abstracts – before 30 June 1997; Submission of full papers – 25 July 1997; Registration fee – Rs. 1000.00.
For further details contact: *Dr. N. K.Nayar, Associate Director of Research, RARS, Pattambi, Kerala, India 679306*. Registration fee should be remitted immediately on acceptance of abstracts, or else sorry to report that the abstracts won't be included in the proceedings.

Indian Institute of Science Bangalore - 560012

Applications are invited from Indian nationals preferably below the age of 35 years for a faculty position at the level of Assistant Professor in the Centre for Ecological Sciences. The candidates, if selected are expected to develop and maintain independent research in any chosen area of ecology, behaviour and evolutionary biology as well as collaborate with other faculty and contribute to the teaching programme.
The candidates should have Ph. D. degree with about 3 years of postdoctoral research experience. Those who wish to develop new programmes of research in areas other than those in which they are presently working, or whose interests bridge basic and applied research are also encouraged to apply. Small start-up funds could be provided. The total emoluments at the minimum of the scale (Rs. 3700-125-4950-150-5700) are around Rs. 1,23,000.00 per annum. Interested persons should send (1) Curriculum vitae list of publications, important reprints and names and addresses of three referees and (2) a brief description of the proposed research programme and the minimum facilities required for carrying it out, to Prof. M. Vijayan, Chairman, Division of Biological Sciences, Indian Institute of Science, Bangalore 560012, India, within 45 days of the appearance of this advertisement. The referees may be requested to send their assessment directly to Prof. Vijayan.
For further details, please contact the Chairman, Centre of Ecological Sciences at email address: `ragh@ces.iisc.ernet.in` or visit CES home page `http:\\ces.iisc.ernet.in`.

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AUTHOR INDEX

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SHORT COMMUNICATIONS

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